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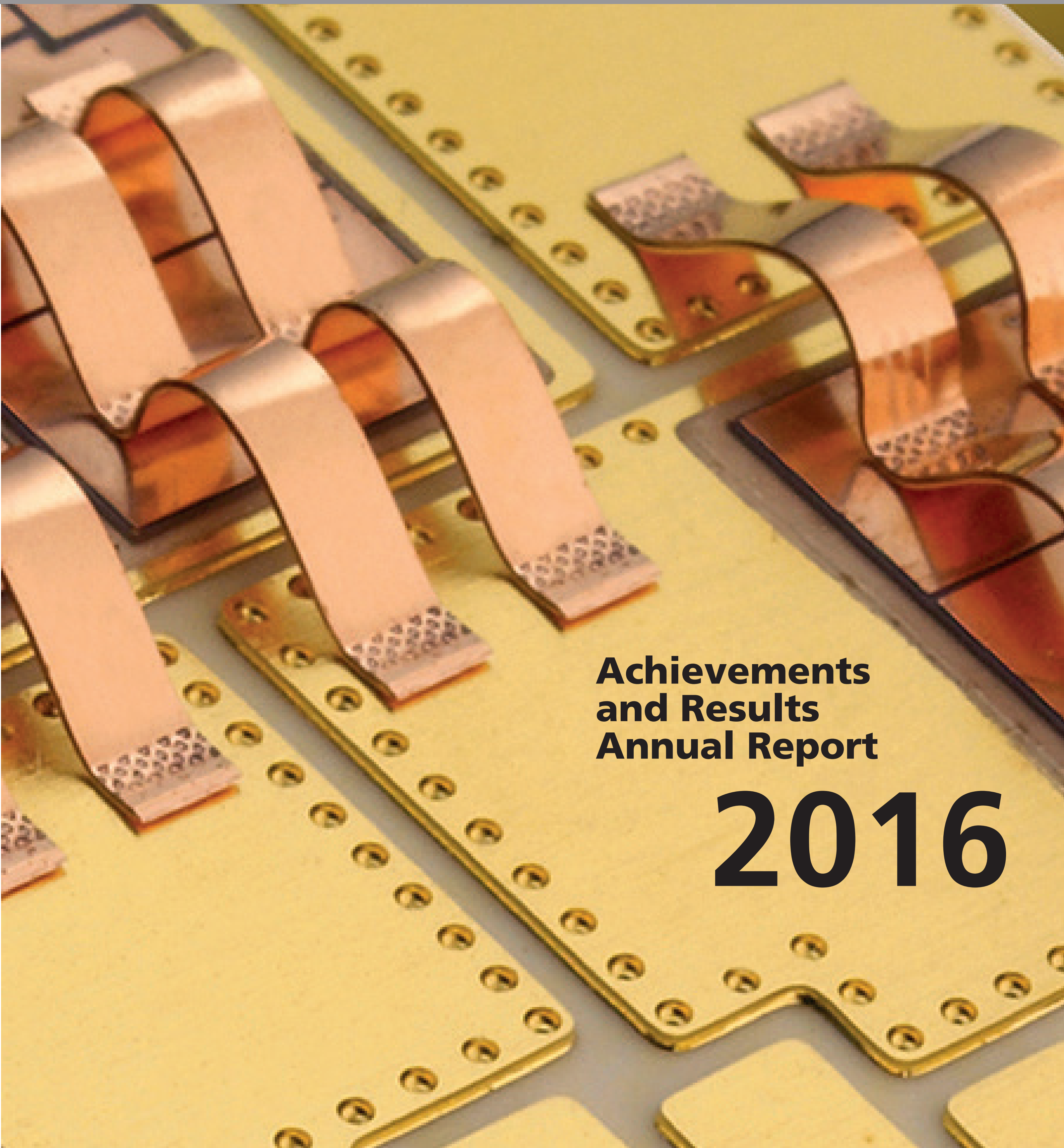
FRAUNHOFER-INSTITUT FÜR SILIZIUMTECHNOLOGIE ISIT



Achievements and Results Annual Report 2016

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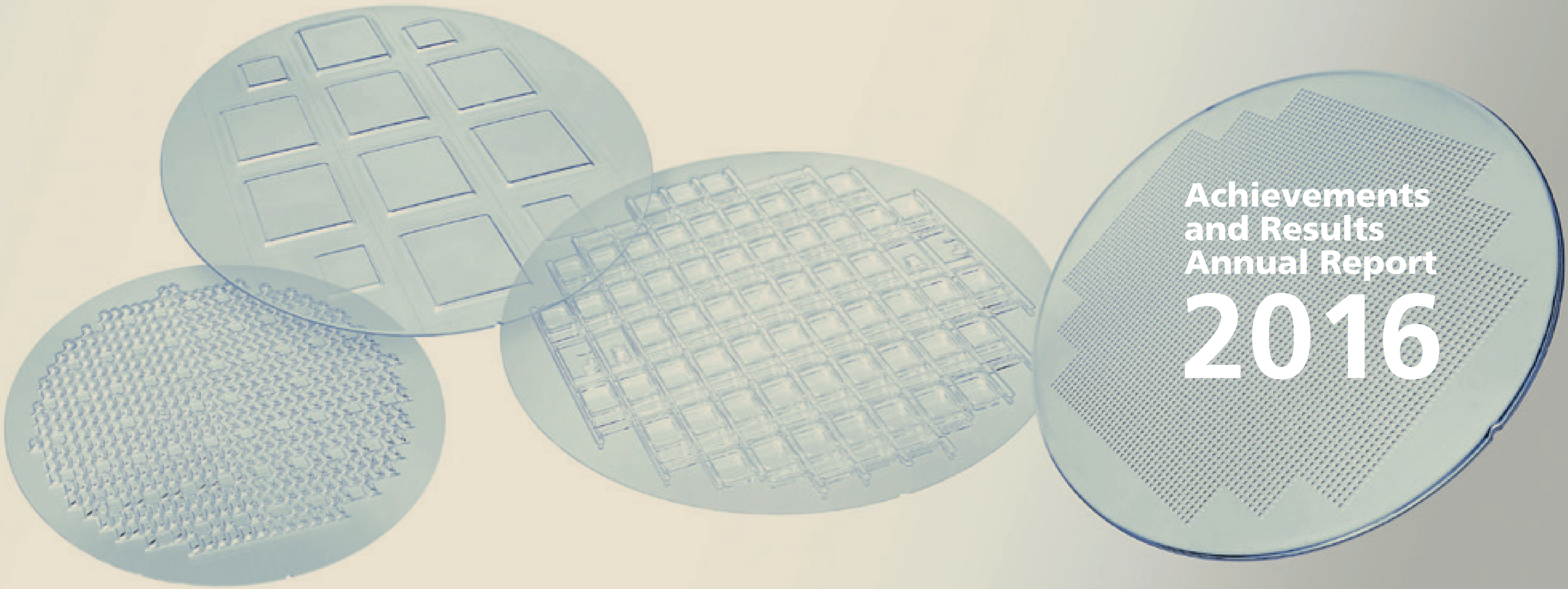
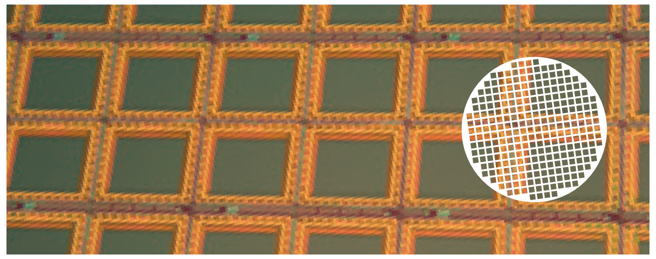
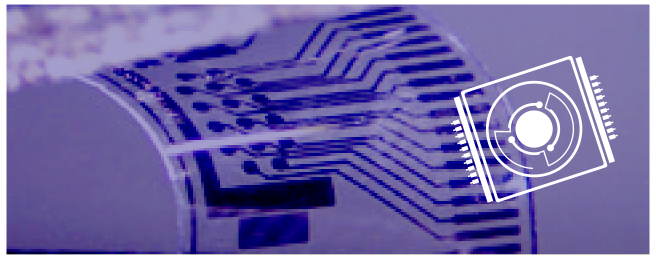


Different glass wafer for optopackages on wafer level

ANNUAL REPORT 2016

Customer specific test substrate for adhesive screening





REPRESENTATIVE RESULTS OF WORK

PREFACE

Dr. Axel Müller-Groeling and
Prof. Dr. Wolfgang Benecke

Dear business partners, dear friends of ISIT, dear colleagues,

We, Dr. Axel Müller-Groeling and Prof. Dr. Wolfgang Benecke, have been leading Fraunhofer ISIT together since 1 October 2016.

We decided on dual leadership since Mr. Benecke will reach retirement age in two years and we want to ensure the continuity of institute management. Our common goal is to continue strengthening ISIT for the coming years, thematically and organizationally, so that the institute will keep on living up to its name as a leading research institution for microsystems technology and power electronics in the future. We will position the institute to continue serving as an important driving force of tomorrow's technology for the industry.

In 2016 the prospects of the institute have been expanded in particular thanks to the new clean room. The expansion in Itzehoe – one of the nation's most comprehensive research investments – has proven itself as an important strategic element for maintaining ISIT's leading international position. Putting it into operation marked the start of a new era at Fraunhofer ISIT and allowed the institute to significantly expand the range of research services it offers.

In addition to close cooperation with Vishay Siliconix in the field of power electronics, the institute has now also established an important strategic partnership with X-FAB MEMS Foundry Itzehoe for the development and production of micro electro mechanical systems (MEMS). The team at X-FAB in Itzehoe has grown to more than 80 employees in the meantime.

Liebe Geschäftspartner, liebe Freunde des ISIT, liebe Kollegen

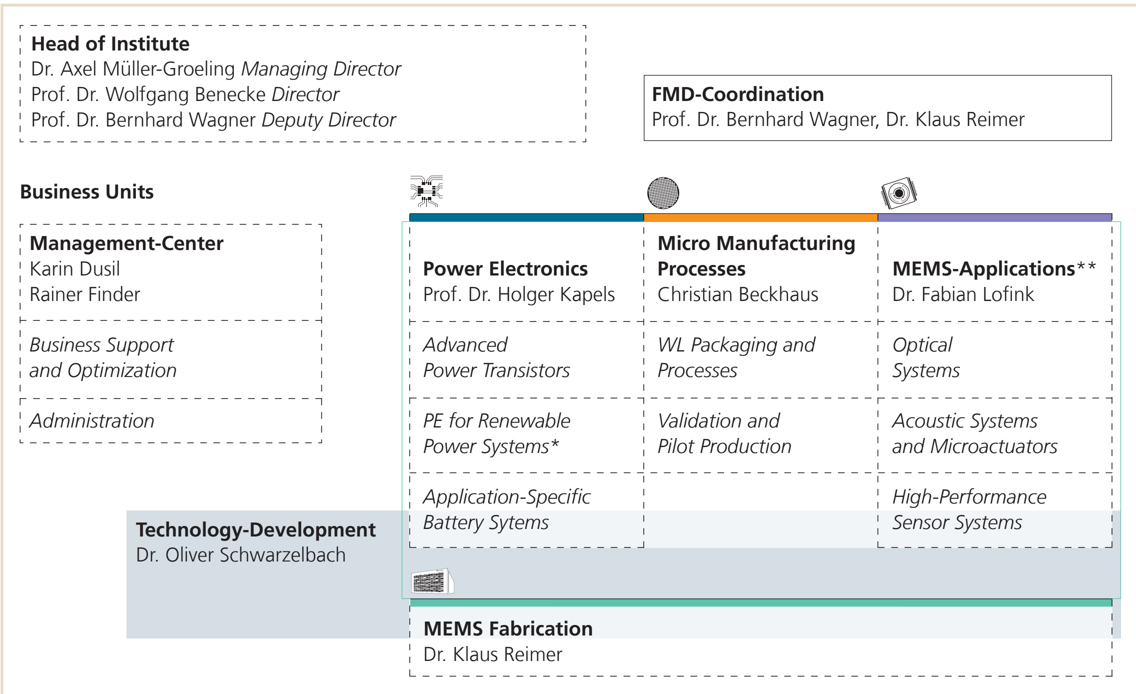
seit dem 1. Oktober 2016 leiten wir, Dr. Axel Müller-Groeling und Prof. Dr. Wolfgang Benecke, das Fraunhofer ISIT gemeinsam.

Wir haben uns zu einer Doppelspitze entschieden, da Herr Benecke in zwei Jahren altersbedingt ausscheiden wird und wir die Kontinuität in der Institutsleitung sicherstellen wollen. Wir verfolgen gemeinsam das Ziel, das ISIT thematisch und organisatorisch für die kommenden Jahre weiter zu stärken, damit das Institut auch in der Zukunft seinem Anspruch als führende Forschungseinrichtung für Mikrosystemtechnik und Leistungselektronik gerecht wird. Wir werden das Institut so aufstellen, dass es der Industrie auch weiterhin ein wichtiger Impulsgeber für die Technik von Morgen bleibt.

Erweiterte Perspektiven für das Institut haben sich in 2016 vor allem durch den neuen Reinraum entwickelt. Der Ausbau in Itzehoe – eine der umfangreichsten Forschungsinvestitionen des Landes – hat sich als ein wichtiges strategisches Element zur Sicherstellung der internationalen Spitzenstellung des ISIT erwiesen. Die Inbetriebnahme hat eine neue Ära beim Fraunhofer ISIT eingeleitet und das Institut konnte seine Angebotspalette an Forschungsdienstleistungen erheblich erweitern.

Neben der intensiven Zusammenarbeit mit der Vishay Siliconix auf dem Gebiet der Leistungselektronik hat das Institut nun eine bedeutende strategische Partnerschaft auch mit der X-FAB MEMS Foundry Itzehoe für die Entwicklung und Fertigung von mikroelektromechanischen Systemen (MEMS) aufgebaut. Die Mannschaft von X-FAB in Itzehoe ist mittlerweile auf über 80 Mitarbeiter angewachsen.

Organizational Chart



* Application Center Hamburg
** with an external office at CAU Kiel and FH Westküste

With this expanded industry cooperation, ISIT has significantly strengthened an important USP in international semiconductor research, namely the fast transfer of innovative power electronics and microsystems technology components to industrial production and applications. The importance of ISIT for the industry can be readily illustrated using two current and socially relevant research projects.

In cooperation with the company IMS Nanofabrication, Fraunhofer ISIT has developed a complex technology in the past years for the fabrication of a switchable aperture array that forms the core element of an innovative multi electron beam mask writing system.

This project is driven by the rapid miniaturization of structures in semiconductor technology. Today focus is on process nodes of 10 nm or less. The decreasing structure dimensions and the increasing structure complexity (e.g. w.r.t. optical proximity correction) result in a huge amount of data and therefore require new fabrication technologies, which could not be satisfied with single electron beam mask writing system. A possible solution is multi electron beam mask writing. The aperture array developed at ISIT together with IMS Nanofabrication permits parallel writing with a few hundred thousand individually deflectable electron beams. In the common development project the metallic electron beam deflection system is monolithically integrated on a preprocessed CMOS wafer. IMS Nanofabrication has now placed a long-term order with ISIT, pursuing the objective of improving the yield and reliability in the direction of suitability for production.

Together with the company USound from Itzehoe, ISIT has developed a new generation of miniaturized MEMS speakers that are produced using silicon technology. Unlike conventional electrodynamic micro-speakers, the new chip speakers are based on high-performance piezoelectric MEMS drivers and set themselves apart with high acoustic

Mit diesen erweiterten Industriekooperationen hat das ISIT ein wichtiges Alleinstellungsmerkmal in der internationalen Halbleiterforschung deutlich ausgebaut, nämlich den schnellen Transfer von innovativen Bauelementen der Leistungselektronik und der Mikrosystemtechnik in die industrielle Produktion und Anwendung. An zwei aktuellen und gesellschaftlich relevanten Forschungsprojekten lässt sich die Bedeutung des ISIT für die Industrie gut aufzeigen.

In Zusammenarbeit mit der Firma IMS Nanofabrication hat das Fraunhofer ISIT in den vergangenen Jahren eine komplexe Technologie zur Herstellung eines schaltbaren Aperturenfeldes entwickelt, welches das Kernelement für einen Multi-Elektronenstrahl Maskenschreiber bildet. Hintergrund für dieses Vorhaben ist die rasante Verkleinerung der Strukturen in der Halbleitertechnologie. Heutzutage geht es um die Darstellung von Strukturen in 10 nm und kleineren Prozessnodes. Die aus schrumpfenden Strukturdimensionen sowie der steigenden Komplexität von Korrekturstrukturen resultierenden großen Datenmengen erfordern neue Technologien, da die Einstrahl-Maskenschreiber in diesen Dimensionen an Ihre Grenzen stoßen. Eine Alternative sind Multistrahl-Maskenschreiber. Das mit IMS am ISIT entwickelte schaltbare Aperturfeld erlaubt ein paralleles Schreiben mit einigen hunderttausend einzeln ablenkbaren Elektronenstrahlen. Dabei wird in dem Entwicklungsvorhaben das metallische Elektronenstrahlablenksystem monolithisch auf einem CMOS Wafer integriert. IMS Nanofabrication hat nun einen langfristigen Auftrag am ISIT mit der Zielsetzung platziert, Ausbeute und Zuverlässigkeit in Richtung Produktionstauglichkeit zu verbessern.

Gemeinsam mit der Firma USound aus Itzehoe hat das ISIT eine neue Generation von miniaturisierten MEMS-Lautsprechern entwickelt, die mittels Siliziumtechnologie gefertigt werden. Im Gegensatz zu konventionellen elektrodynamischen Mikro-Lautsprechern basieren die neuen Chip-Lautsprecher auf leistungsfähigen piezo-elektrischen MEMS-Antrieben und zeichnen sich durch eine hohe

Prize winners Lars Blohm and Dr. Thomas Knieling at Ideenwettbewerb Schleswig Holstein with Minister of Economic Affairs Reinhard Meyer

Left: GMM CEO Prof. Christoph Kutter hands over the GMM Prize 2016 to Vanessa Stenchly

Dr. Helmut Bernd (middle) with colleagues and project partners

quality, a small design size, favorable production costs, and low energy consumption. They are intended for use in mobile communication devices such as tablets, smartphones, and headphones (especially in the ear). USound plans to bring headphones with MEMS speakers to market before the end of 2017.

Further evidence that ISIT with its research activities has its finger on the pulse of time can be seen in the fact that ISIT scientists won renowned research prizes in 2016. ISIT scientist Vanessa Stenchly was honored with the GMM prize of 2016. The "Gesellschaft Mikroelektronik, Mikrosystem- und Feinwerktechnik" (GMM) awards an annual prize for the best, distinguished publication in the field of microelectronics and microsystems technology. Ms. Stenchly received the prize endowed at EUR 2500 during a festive event at electronica for her work with the microstructuring of glasses at ISIT. Such glasses with very high optical standards can be used for the wafer level packaging of optically active microcomponents such as sensors or micromirrors, which are also developed at ISIT.

ISIT scientists Lars Bohm, Dr. Thomas Knieling, and Dr. Eric Nebling succeeded in the 2016 "Ideenwettbewerb Schleswig-Holstein" competition. This competition organized by WTSH and the University of Kiel recognizes outstanding ideas with economic potential from Schleswig-Holstein. The team of scientists together with ISIT project partner Jürgen Brink, Managing Director of the company Brink Corporate Development GmbH, received the "Food & Health" special prize. They were recognized for the development of an intelligent mouthpiece that allows athletes to measure the lactate content in their saliva. This value corresponds to the lactate level in the blood and provides information about current muscle fatigue. The mouthpiece transmits the measured value to a smartphone or smartwatch via Bluetooth. Athletes can easily check their own performance with this system and adapt their training accordingly.

akustische Qualität, geringe Baugröße, günstige Fertigungskosten und niedrigen Energieverbrauch aus. Einsatzgebiete sind mobile Kommunikationsgeräte wie Tablets, Smartphones und Kopfhörer (insbesondere im Ohr). USound plant, noch in 2017 einen Kopfhörer mit MEMS-Lautsprechern auf den Markt zu bringen.

Dass das ISIT mit seinen Forschungsaktivitäten am Puls der Zeit arbeitet, lässt sich auch daran ablesen, dass in 2016 ISIT-Wissenschaftlerinnen und Wissenschaftler renommierte Forschungspreise gewonnen haben. So wurde die ISIT-Wissenschaftlerin Vanessa Stenchly mit dem GMM-Preis des Jahres 2016 ausgezeichnet. Die Gesellschaft für Mikroelektronik, Mikrosystem- und Feinwerktechnik (GMM) vergibt jährlich einen Preis für die beste, herausragende Veröffentlichung auf dem Gebiet der Mikroelektronik und Mikrosystemtechnik. Frau Stenchly erhielt den mit 2 500 Euro dotierten Preis im Rahmen einer Festveranstaltung auf der electronica für ihre Arbeiten, die sie im ISIT in der Mikrostrukturierung von Gläsern erzielt hat. Solche Gläser mit hohen optischen Anforderungen können zur Verkapselung auf Waferebene von optisch aktiven Mikrokomponenten wie Sensoren oder Mikrospiegel eingesetzt werden, die ebenfalls am ISIT entwickelt werden.

Die ISIT Wissenschaftler Lars Bohm, Dr. Thomas Knieling und Dr. Eric Nebling waren beim Ideenwettbewerb Schleswig-Holstein 2016 erfolgreich. Der Wettbewerb, organisiert von der WTSH und der Fachhochschule Kiel, zeichnet herausragende Ideen mit wirtschaftlichem Potenzial aus Schleswig-Holstein aus. Das Wissenschaftlerteam erhielt zusammen mit ISIT-Projektpartner Jürgen Brink, Geschäftsführer der Firma Brink Corporate Development GmbH den Sonderpreis „Food & Health". Sie wurden für die Entwicklung eines intelligenten Mundstückes ausgezeichnet, mit dem Sportler den Laktatgehalt in ihrem Speichel messen können. Dieser Wert korrespondiert mit dem Laktatgehalt im Blut und gibt Auskunft über den aktuellen Ermüdungszustand der

Wayne Lukes, member of the Vishay organization team for the open day in High Tech Itzehoe

The Itzehoe high-tech site began 20 years ago with the establishment of Fraunhofer ISIT, the company Vishay Siliconix Itzehoe GmbH, and the founding of the IZET Innovation Center. Today more than 50 companies with over 1,300 jobs are at home at the technology site in Itzehoe Nord. This was cause to celebrate.

The entire innovation park opened its doors to visitors on Saturday, September 10 under the motto "20 years high-tech and innovation in Itzehoe". Companies provided information about their products, granted insights into production and development, or presented their business activities in the exhibitions in the IZET Innovation Center or at Fraunhofer ISIT. Entertainment, fun, and games were provided along with food and drink at the various locations. A shuttle bus service was provided especially for interested visitors to see all the attractions in the 50-hectare innovation park. The day was a huge success. More than 1500 visitors took advantage of the offering in glorious weather and were inspired by the enthusiasm and dedication of the employees.

Muskulatur. Das Mundstück übermittelt die gemessenen Werte per Bluetooth an ein Smartphone oder eine Smartwatch. Mit diesem System können Sportler ihre Leistungsfähigkeit ganz einfach selbst überprüfen und ihr Training entsprechend anpassen.

Der Auftakt der Erfolgsgeschichte des Hightech Standortes Itzehoe begann vor 20 Jahren mit der Ansiedlung des Fraunhofer ISIT, des Unternehmens Vishay Siliconix Itzehoe GmbH und der Gründung des IZET Innovationszentrums. Heute sind über 50 Unternehmen mit mehr als 1 300 Arbeitsplätzen am Technologiestandort in Itzehoe Nord zu Hause. Dies war ein Anlass zum zum Feiern.

Am Samstag, den 10. September, wurden unter dem Motto „20 Jahre Hightech und Innovationen in Itzehoe" die Türen im gesamten Innovationspark für Besucher geöffnet. Die Firmen informierten über ihre Produkte, gewährten Einblick in Fertigung und Entwicklung oder zeigten ihr Leistungsspektrum in den Ausstellungen im IZET Innovationszentrum oder Fraunhofer ISIT. Für Unterhaltung, Spaß und Spiel war ebenso gesorgt, wie für Essen und Trinken an den unterschiedlichen Standorten. Die interessierten Besucher konnten den extra eingerichteten Bus-Shuttle nutzen, um alle Attraktionen im 50 ha umfassenden Innovationspark zu besuchen. Der Tag war ein großer Erfolg; mehr als 1 500 Besucher nutzten bei schönstem Wetter das Angebot und ließen sich anstecken von der Begeisterung und dem Engagement der Mitarbeiter.

Ein weiteres Jubiläum, an dem sich das ISIT beteiligte, gab es am 1. und 2. Oktober. Das Land Schleswig-Holstein feierte mit einem Festakt und einem Bürgerfest in Eutin den 70. Geburtstag des Landes. Das ISIT präsentierte sich auf dem Festgelände mit Mitmachaktionen und einer Technik-Ausstellung. Die ISIT-Wissenschaftler zeigten einem breiten Laienpublikum wie Mikrochips hergestellt werden und wo sie überall im Alltag zu finden sind.

Impressions of the open day at High Tech Itzehoe; bottom left: Prof. Ralf Dudde

ISIT participated in another anniversary on October 1 and 2. The state of Schleswig-Holstein celebrated its 70th birthday with a ceremonial act and a public festival in Eutin. ISIT presented itself at the festival site with hands-on activities and a technology exhibition. The ISIT scientists showed the public how microchips are made and where they are found in everyday life.

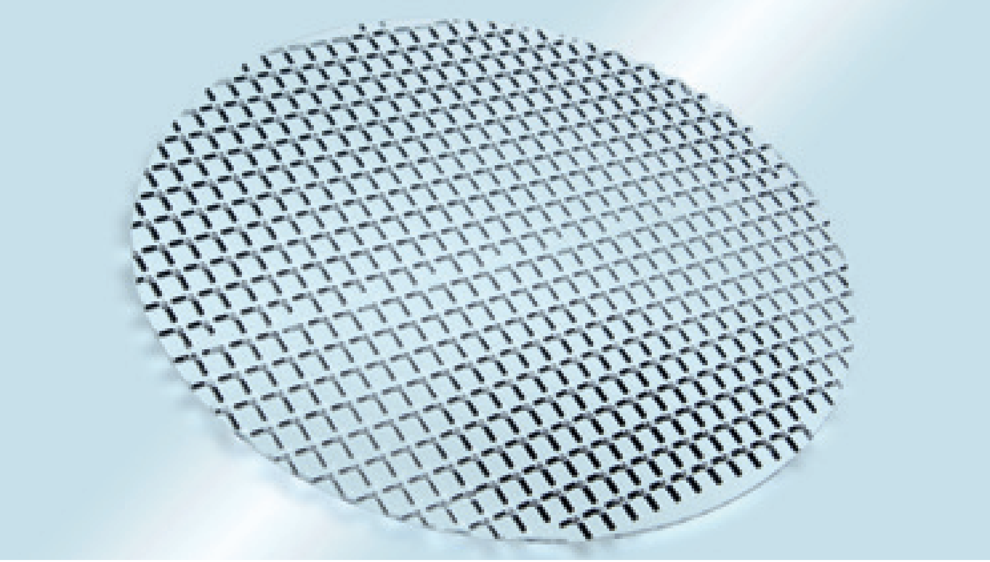
After twenty years of development, ISIT is currently in the midst of a generation change. Colleagues who conceived and built up ISIT starting from Berlin are reaching retirement. In 2016 Dr. Helmut Bernt was among them from the expanded management of the institute. The physicist joined the Fraunhofer Society back in 1966 in Munich.
He accompanied the development of the ISIT predecessor institute IMT (Institute for Microstructure Technology) in Berlin starting in 1985 and was active at ISIT in a high-level scientific position from 1996 to 2016. In the name of all colleagues we thank him for his outstanding contribution to ISIT and the Fraunhofer Society.

The last few months at ISIT were defined by intensive strategic dialog between the management and the employees. Tough competition for the best ideas and shortening technology innovation cycles are forcing even ISIT to follow a process of constant questioning and continuous improvement. ISIT rises to this challenge in the awareness that this is the only way to remain the partner and pioneer those customers and industry partners rightfully expect. As the first visible result of these efforts, ISIT is restructuring its R&D

Nach zwanzig Jahren Aufbauarbeit vollzieht sich im ISIT zur Zeit ein Generationswechsel. Kolleginnen und Kollegen, die schon von Berlin aus das ISIT konzipiert und aufgebaut haben, erreichen ihren Ruhestand. Aus der erweiterten Führung des Instituts betraf das in 2016 Dr. Helmut Bernt. Der Physiker kam bereits 1966 zur Fraunhofer-Gesellschaft in München.
Er hat ab 1985 den Aufbau des ISIT- Vorgängerinstitutes IMT (Institut für Mikrostrukturtechnik) in Berlin begleitet und war in den Jahren 1996 bis 2016 in hervorgehobener wissenschaftlicher Position im ISIT tätig. Im Namen aller Kolleginnen und Kollegen bedanken wir uns für sein hervorragendes Wirken für das ISIT und die Fraunhofer-Gesellschaft.

Die letzten Monate standen am ISIT im Zeichen eines intensiven strategischen Dialogs unter den Führungskräften und Mitarbeitern. Intensiver Wettbewerb um die besten Ideen und sich verkürzende technologische Innovationszyklen zwingen auch das ISIT in einen Prozess des ständigen Hinterfragens und fortlaufenden Verbesserns. Dem stellt sich das ISIT in dem Bewusstsein, nur auf diese Weise der Partner und Vordenker bleiben zu können, den Kunden und Industriepartner zu Recht erwarten. Als erstes sichtbares Ergebnis dieses Bemühens gibt sich das ISIT in seinen F&E-Bereichen eine neue, noch stärker an den Kundenbedarfen orientierte Struktur. An die Stelle der bisherigen Abteilungen treten drei Geschäftsfelder. Das Geschäftsfeld „Leistungselektronik“ befasst sich mit dem Design, der Entwicklung und der Herstellung von leistungselektronischen Komponenten und Systemen.
Dazu gehören innovative Leistungstransistoren ebenso wie

ISIT trainees Jana Kern and Laura Gersmeier with their trainee manager Anja Ambrosius at an educational fair for girls at ISIT



With glass reflow structured wafer for optical MEMS

departments to be even more closely oriented towards customer needs. The previous departments are being replaced by three business units. The Business Unit Power Electronics is dedicated to the design, development, and manufacturing of power electronics components and systems. This includes innovative power transistors as well as intelligent converters. Key application markets are regenerative energies and e-mobility. The Business Unit Micro-Manufacturing Methods deals with methods, processes, and services for microelectronic and micromechanical production. Here ISIT appears as an adviser, problem solver, and technology supplier on the one hand and, on the other hand, as a specialist in close cooperation with its industry partners for transferring prototype solutions to series production. The Business Unit MEMS Applications is dedicated to the development and production of micro electro mechanical systems (MEMS) and components. Key focal points here are optical systems such microscanners, acoustic systems and the corresponding high-performance microdrives, and highly sensitive sensor systems. One thing these MEMS applications have in common is that the field of application is unusually broad, ranging from virtual reality products to hearing aids and diagnostic-medical applications to autonomous driving and generative production methods (3D printing). The new clean room as the heart of the technology facilities at ISIT forms a separate organization unit "Fab" dedicated solely to the efficient and effective operation of this infrastructure.

intelligente Stromrichter. Wesentliche Anwendungsmärkte sind regenerative Energien und E-Mobilität. Das Geschäftsfeld „Mikro-Fertigungsverfahren" beschäftigt sich mit Verfahren, Prozessen und Services für die mikroelektronische und mikromechanische Produktion. Hier tritt das ISIT einerseits als Berater, Problemlöser und Technologie-Lieferant auf, andererseits in enger Zusammenarbeit mit seinen Industriepartnern als Spezialist für die Überführung von prototypischen Lösungen in die Serienfertigung. Im Geschäftsfeld „MEMS-Anwendungen" dreht sich alles um die Entwicklung und Herstellung von mikroelektromechanischen („MEMS") Komponenten und Systemen. Besondere Schwerpunkte liegen hierbei im Bereich optischer Systeme, wie etwa der Mikro-Scanner, bei akustischen Systemen und den dazugehörigen leistungsstarken Mikroantrieben sowie bei hochempfindlichen Sensorsystemen. Diesen MEMS-Anwendungen gemein sind ihre ungewöhnlich breiten Anwendungsfelder, die von Virtual-Reality-Produkten über Hörgeräte und diagnostisch-medizinischen Anwendungen bis zu autonomem Fahren und generativen Fertigungsverfahren („3D-Druck") reichen. Das Herzstück der technologischen Ausstattung des ISIT, der neue Reinraum, bildet eine eigene, ausschließlich auf das effiziente und effektive Betreiben dieser Infrastruktur ausgerichtete Organisationseinheit, die „Fab".

So aufgestellt, fühlt sich das ISIT gut gerüstet, auch den finanziellen Herausforderungen der nächsten Zeit zu begegnen. Immerhin fast 80 Prozent unsere Budgets müssen wir im Wettbewerb am Markt erwirtschaften. Neben

ISIT Board of Trustees

Thanks to its position, ISIT feels well prepared to also overcome the financial challenges of the near future. We need to generate nearly 80 per cent of our budget in the competitive market. In addition to the most effective possible structures, employee qualifications and their innovative thinking ability are of crucial importance here. The work of the institute to date clearly confirms that ISIT and its employees have this ability. We would like to take this opportunity to thank all employees for their dedication and great performance. Our thanks also to all partners, customers and sponsors for their trust and cooperation.

We look forward to exchanging ideas with you!

möglichst effektiven Strukturen ist hierfür vor allem die Qualifikation der Mitarbeiter und ihrer Fähigkeit zu innovativem Denken von entscheidender Bedeutung. Dass das ISIT und seine Mitarbeiter diese Fähigkeit besitzen, lässt sich aus der bisherigen Arbeit des Instituts mit Nachdruck belegen. Für dieses Engagement und die erhebliche Arbeitsleistung möchten wir uns bei allen Mitarbeiterinnen und Mitarbeitern an dieser Stelle bedanken. Danken möchten wir auch allen Partnern, Auftraggebern und Förderern für die vertrauensvolle Zusammenarbeit.

Wir freuen uns auf den Gedankenaustausch mit Ihnen!

Dr. A. Müller-Groeling

Prof. W. Benecke

FRAUNHOFER-INSTITUT FÜR SILIZIUMTECHNOLOGIE (ISIT)

Research and Production in one Location

The Fraunhofer Institute for Silicon Technology ISIT develops and produces power electronics and microsystems according to customers specifications. Important areas of application include energy technology, automotive and transport engineering, the consumer goods industry, medical technology, communications technology, and automation. Ultra-modern technological equipment based on 200 mm silicon wafer technology and expertise built up over decades put Fraunhofer ISIT and its customers at the forefront of the field worldwide.

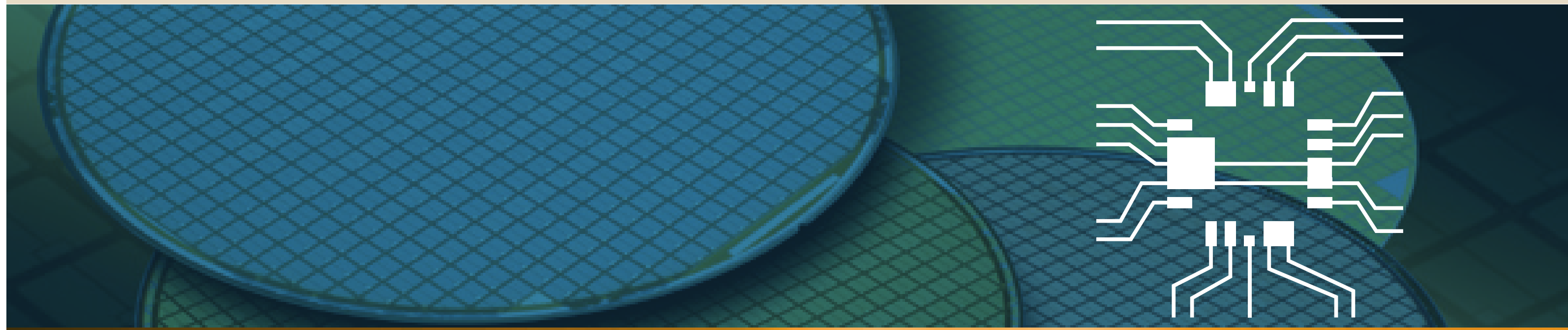
Fraunhofer ISIT supports customers right the way from design and system simulation to the production of prototypes, samples, and preparation for series production. The institute currently employs a staff of 160 persons with engineering and natural sciences backgrounds.

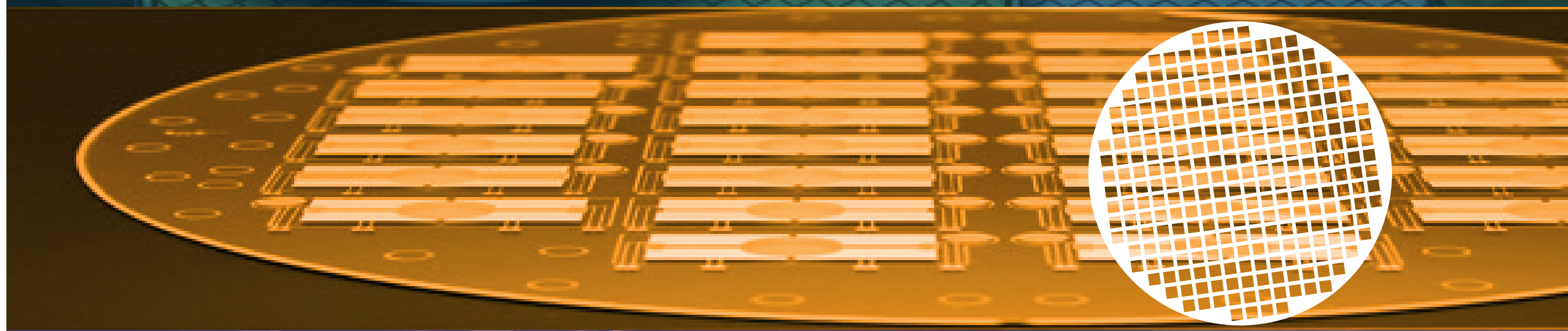
Fraunhofer ISIT deals with all the important aspects of system integration, assembly and interconnection technology (packaging), and the reliability and quality of components, modules, and systems. The institute also provides manufacturing support for application-specific integrated circuits (ASICs) to operate sensors and actuators. Activities are rounded off by the development of electrical energy storage devices, with a focus on Li-polymer batteries.

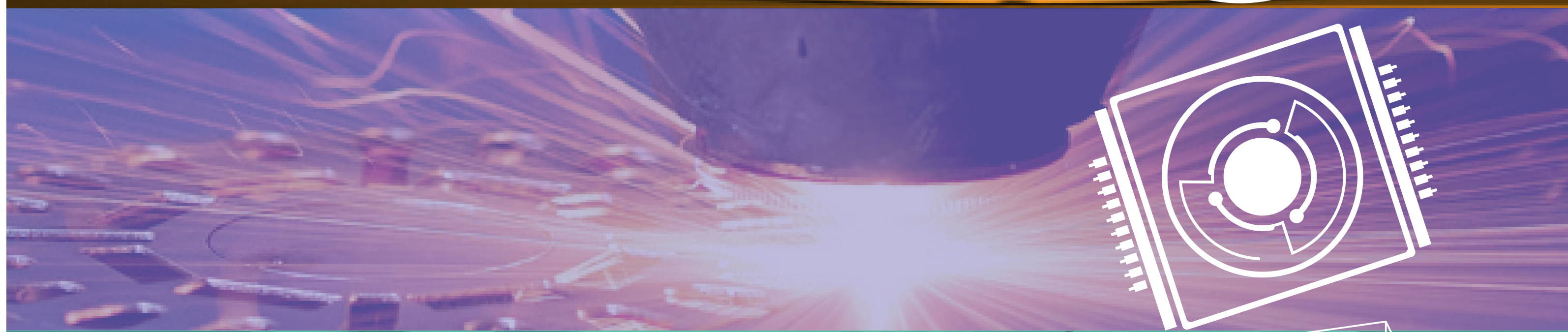
One point that really sets Fraunhofer ISIT apart is the speed with which it can transfer innovative developments into industrial application and production. To this end, Fraunhofer ISIT operates a wafer production line in its cleanrooms in collaboration with the companies Vishay and X-FAB MEMS Foundry Itzehoe. There are longstanding collaborations with a variety of manufacturing companies local to Fraunhofer ISIT.

Fraunhofer ISIT runs an application center at Hamburg University of Applied Sciences, a project group at the University of Applied Sciences in Heide, and a working group at the Christian-Albrechts-Universität in Kiel.

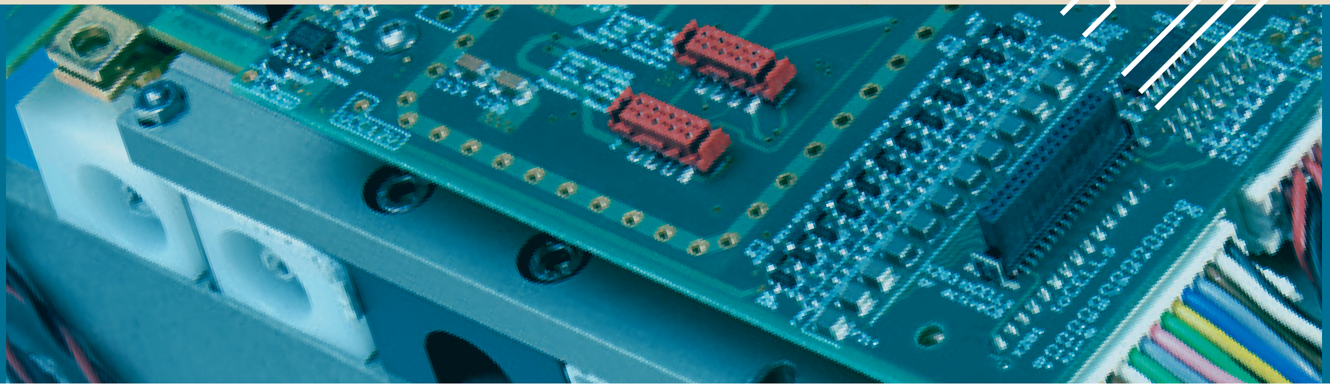
BUSINESS UNITS







POWER ELECTRONICS



Battery management system with single cell monitoring

The Business Unit Power Electronics develops and manufactures active and passive semiconductor components, integrates them into power electronics systems, and is engaged in the field of high-performance batteries for specialized applications.

The active devices are primarily PowerMOS transistors, IGBTs, silicon-based diodes as well as novel power semiconductors based on gallium nitride. The R&D focuses in particular on the application-specific design of the components and the development of new device architectures. Another important research topic is the development of new processes for innovative assembly techniques of power components on wafer level. Application-specific devices for the development of new interconnect and assembly techniques can be produced with special metallization schemes, adapted device structures, and special pad configurations. Novel carrier concepts were developed for backside-processing of ultra-thin silicon substrates, enabling laser processing of power semiconductor devices. These laser-based processes are targeting customer-specific optimizations of static and dynamic losses while simultaneously increasing the device robustness. Numerous simulation, design and testing tools are supporting the work. Here ISIT can rely on many years of R&D experience in the design and manufacturing of CMOS circuits.

The development of passive electronic components focuses primarily on chip capacitors, precision resistors, inductors, and the corresponding circuits on chip level. This involves also the evaluation of new materials and the implementation in existing processes.

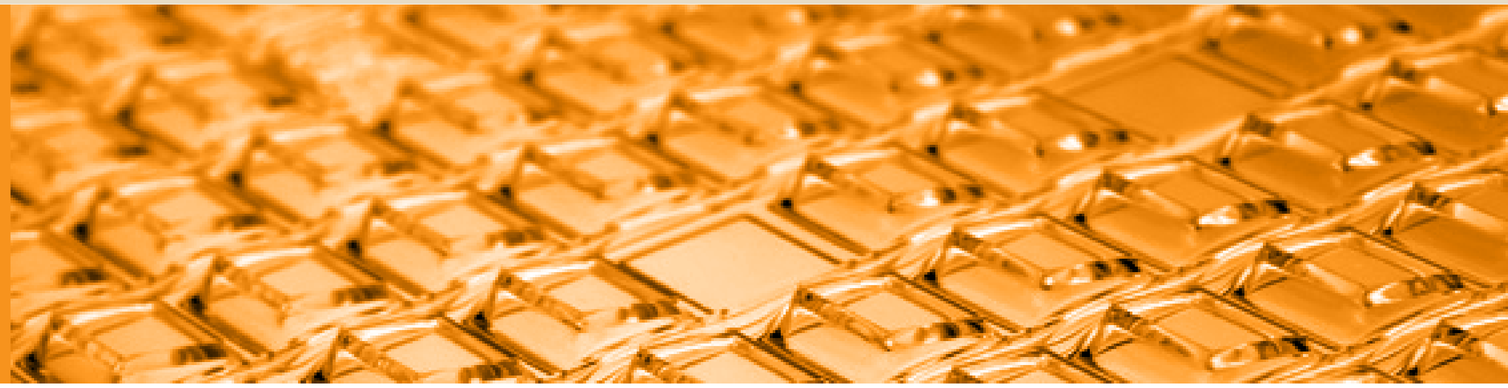
ISIT develops specific processes, process modules, and complete process sequences for various applications. The ISIT also offers customer-specific processing of silicon components in small to medium quantities as a service, based on a qualified semiconductor process technology.

On system level, the ISIT is engaged primarily in highly efficient power converters. ISIT develops new circuits and circuit topologies using application-specific power semiconductors targeting an optimized overall system behavior and increased long-term reliability. Key fields of application for these ISIT services are in the fields of renewable energies and e-mobility, especially DC/DC and DC/AC converters.

The lithium-polymer based battery storage technology developed by ISIT enables a wide adaptability to specific requirement profiles, for example in terms of temperature ranges, load capacity, durability and safety requirements. This also includes the conceptual design of adapted housings. Li-polymer technology is based on the fact that all components of the accumulator are first produced as films. At the ISIT, the complete process chain is available from the paste processing to the film casting and the assembly of complete accumulators up to the electrical and thermomechanical characterization. Thus, it is possible to access all parameters relevant for an optimization process, from the processing of the electrode materials through the electrolytes to the design.

ISIT coordinates the Schleswig-Holstein power electronics network in the field of power electronics to intensify cooperation with end users and manufacturers of power electronics systems, and to initiate and organize research projects.

MICRO MANUFACTURING PROCESSES



Wafer with tilted glass windows for scanner applications

This business unit focuses on the processes, procedures, and services that constitute essential prerequisites for research and development in the Business Unit MEMS Applications on the one hand and, on the other hand, also services offered by ISIT directly in the market.

Important offerings at ISIT are wafer-level packaging (WLP) and various individual processes at the wafer level. Here the focus is on the packaging of microsystems on the wafer (for instance with a defined interior pressure), but also the further processing of pre-structured wafers and the development of problem-specific technology solutions at the individual process level. The wafer technologies that are developed not only make it possible to optimize packaging in terms of cost and component size reduction, but also to make it a functional part of a microsystem. Examples are integrated optical functionality (glass cap wafers) and direct MEMS and ASIC interconnection (electrical through contacting on the wafer level). Outstanding successes were achieved in the vacuum capping of MEMS sensors by means of eutectic wafer bonding. The technology basis at ISIT is excellent: Front-end processes of the Business Unit Power Electronic Systems and the own back-end clean room line with equipment for MEMS-specific manufacturing processes can be used. The lithographic capabilities include a wide-field stepper, backside mask aligner, spray coating and spin coating, and thick resist processing. CVD, PVD, and ALD tools for the deposition of poly-Si, SiGe, SiO_2, SiN, Ge, Au, Pt, Ir, Ag, Al, Cu, Ni, Cr, Mo, Ta, Ti, TiN, TiW, Al_2O_3, AlN, PZT and other thin films are available. The wet processing area comprises anisotropic etching of Si, automated tools for metal etching, and electroplating of Au, Cu and Sn. In case of dry etching, equipment for DRIE of Si and RIE of oxidic compounds is available. MEMS release etching can be performed using HF and XeF_2 gas phase etching or wet etching followed by critical point drying. A specific focus is given to hermetic wafer level packaging of MEMS using metallic, anodic, or glass frit wafer bonding technology. Wafer grinding and temporary wafer bonding are key process steps for thin wafer and 3D integrated products including through silicon vias (TSV). In addition to the individual processes, ISIT has established a number of qualified technology platforms. Examples are the thick poly-Si surface micro-machining platform for capacitive sensors/actuators and the piezoelectric MEMS platform. In the latter case, sputtered thin PZT or AlN layers with suitable bottom and top electrodes are integrated in a complete process flow for piezoelectric MEMS transducers.

ISIT can also offer the developed components and systems to customers as prototypes or in small series from pilot production. Not only does this require proving that certain manufacturing steps and functional principles are feasible in principle, for example using demonstrators, but also taking all development steps to series readiness – an effort that must not be underestimated. High volume series production can be supported in particular through cooperation with the local company X-FAB MEMS Foundry Itzehoe GmbH, so that the industrial production of larger quantities is also possible in many cases.

Finally ISIT offers a number of services at the module level to internal and external customers as module services. In assembly and interconnection technology, ISIT specializes in the implementation of innovative processes and technologies in direct cooperation with manufacturers of assemblies, equipment, and materials. The automatic assembly of ultra-thin chips on flexible PCBs has already been tested successfully several years ago. ISIT has all basic technologies for the automated or manual handling of microchips and MEMS as well as their electrical contacting using wire bonding and flip-chip technologies. For power electronics assemblies with improved power cycle performance, ISIT has highly developed thick wire/ribbon bonding technology, both for aluminum and for copper bonding material up to cross-sections of 200 µm x 2000 µm. ISIT has 20 years of experience with the assessment of quality, reliability, and robustness. Focal points are on the assessment of manufacturing quality, reliability testing, lifetime prediction and failure analysis, and the development of electronics as well as assembly and interconnect concepts, from the chip to the system. Beyond that, ISIT evaluates the aging behavior of assembly and interconnect techniques like chip-on-chip, chip-on-system, chip-on-board, and chip-on-polymer as well as bonding and soldering connections.

The scientists work on the basis of a requirements' matrix and customer specifications to create prognostics by means of model calculations, analyses under different environmental conditions, and accelerated aging tests. They also conduct extensive assessments of failure analyses in the prognostics.

MEMS APPLICATIONS

Flexible biosensors for glucose or lactate analysis in body fluids

ISIT scientists have been working on the development of micro electro mechanical systems (MEMS) for more than 30 years. In the Business Unit MEMS Applications, ISIT focuses on the design, development, and production of MEMS components and MEMS systems.

Optical microsystems are a key focal point in this business unit. Here ISIT develops MEMS scanners, that are scanning micromirrors including control and read out electronics for different kinds of laser projection displays, beam forming methods, optical measuring and detection systems (such as LIDAR), and power applications in the fields of laser material processing and generative manufacturing. Based on a patented fabrication process, ISIT is currently the world's only manufacturer of wafer-level vacuum packaged dual-axis MEMS scanners. Operating these scanning micromirrors in a local vacuum environment offers significant advantages.

Damping by the gas molecules is reduced to a minimum, enabling high-frequency scanning with unrivaled scan angles even at low electrostatic driving voltages. Hermetic encapsulation at the wafer level also results in the cost-effective and permanent protection of the scanning micromirrors against all kinds of contamination. This for example makes the steam sterilization of these MEMS scanners in an autoclave for endoscopy applications possible without causing damage.

ISIT has also realized a 3D camera with a depth resolution of just a few millimeters and a detectable object distance of 2 meters on the basis of 2D MEMS scanners. Novel scanning micromirrors with apertures of up to 2 centimeters and highly reflective coatings even permit highly dynamic dual-axis laser beam deflection for CW laser outputs of up to 500 watts. In addition to capacitively driven scanning micromirrors, piezoelectrically driven scanning micromirrors are currently a research focal point at ISIT.
This drive concept is particularly attractive due to its potential high force with simultaneous low energy consumption. Deflections of up to 1600 µm have already been realized on individual scanning micromirrors of this type for resonant, translatory lifting movements.

Another field of work of this business unit includes acoustic systems and the corresponding high-performance micro-actuators. Here a focus is on the development of MEMS microphones and speakers. These can be produced much more cost effectively and more miniaturized in at least the same acoustic quality as their conventional electrodynamic equivalents. The high energy efficiency of these components is another advantage. This makes the ISIT chip microphones and speakers especially attractive for mobile communication devices such as tablets, smartphones, headphones, and hearing aids that require high acoustic quality and low energy consumption while the component size has to keep shrinking.

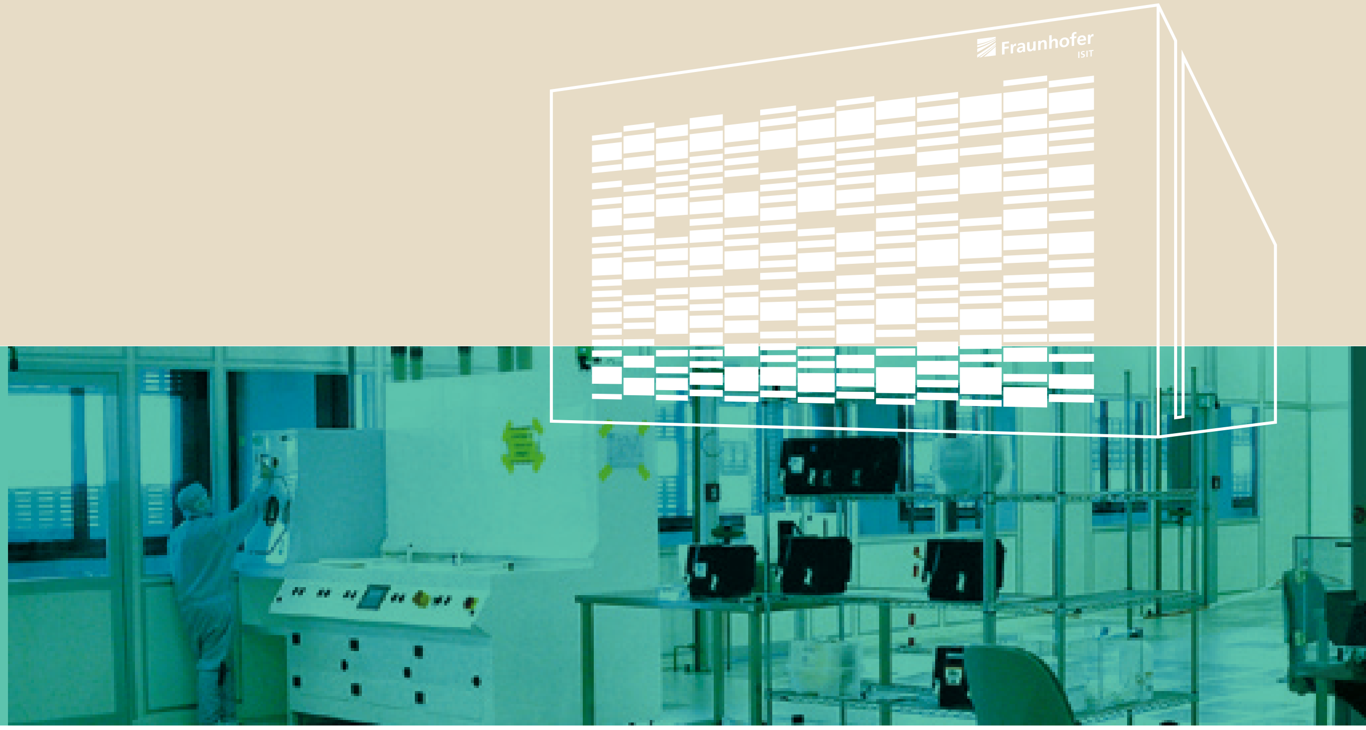
Miniaturized ultrasonic transducers are another focal point aside from the MEMS speakers. Depending on the frequency range, the transducers at ISIT are usually designed as thickness-mode or membrane transducers with AlN, AlScN, or PZT available as drive materials. Efficient ultrasound transducers with center frequencies of a few kHz to several hundred MHz can be realized this way.
The developed components include ultrasound arrays for medical technology, non-destructive testing, and gesture recognition.

The business unit is also involved in sensor applications with a focus on high detection sensitivity. Highly sensitive magnetic field sensors are a key example here. They are intended for advancing into the femtotesla range without superconductivity for the non-invasive measurement and monitoring of important body functions such as heart and brain signals. The long-term objective is, on the one hand, to integrate such and similar diagnostic capabilities into clothing, glasses, or hats (wearables), in order to make many examination procedures that are highly specialized today a standardized matter of course.

On the other hand, this should also enable the contactless control of machines using gestures, eye movements, or even thoughts (human-brain interface).

Biotechnology microsystems for miniaturized and mobile analysis platforms are another development trend (point-of-care diagnostics). In addition to reliability and reproducibility, high sensitivity tops the list of requirements here as well. Microelectrode arrays in combination with microfluidics components and integrated electronics thereby enable the qualitative and quantitative detection of DNA, RNA, proteins, and haptens.

MEMS FABRICATION



ISIT cleanroom

Facilities, Equipment and Processes

Fraunhofer ISIT has access to a 200 mm Silicon technology line (2.500 m^2) for front-end processes (MOS and PowerMOS).
In a special newly built cleanroom (1.000 m^2) specific processes for MEMS and NEMS as well as for packaging are implemented. This includes wet etching, dry etching, DRIE, deposition of non-IC-compatible materials, lithography with thick-resist layers, electroplating, microshaping, and wafer bonding. Further cleanroom laboratories are set up for chemical-mechanical polishing (CMP) and post-CMP processing.
The institute's facilities have been certified to ISO 9001:2008 for many years.

Individual Processes

At ISIT all technologies are available to cover the complete process chain from wafer start to wafer endtest.
Main focus is on MEMS specific technologies like photo lithography in thick resist layer, deep reactive ion etching, electroplating, several wafer bond processes as well as glass forming.

- Lithography
- Plasma-Enhanced Chemical Vapor Deposition (PECVD)
- Chemical Vapor Deposition (CVD)
- Sputtering and Evaporation
- Atomic Layer Deposition (ALD)
- Electroplating
- Deep Reactive Ion Etching (DRIE)
- Reactive Ion Etching (RIE)
- Waferdicing and Grinding

For process details look at "http://www.isit.fraunhofer.de/de/Arbeitsgebiete/Mikrosystemtechnik/Einzelprozesse.html"

Technology-Platforms

ISIT has a wide portfolio of qualified single process technologies available, which were combined to specific MEMS-Process Platforms. They form a kind of tool box to realize the different applications.

PSM-X2 Process Platform

The technology platform PSM-X2 features a low stress 10-30 µm thick poly silicon layer for the realisation of mechanical active and passive MEMS structures. The use of high resolution lithography allows minimal structure dimension down to 0.5µm. An additional electrode layer beneath the active polysilicon layer is implemented. This gives the opportunity for out-of-plane signal detection or sensor stimulation. Additive functional layers enhance reliability and robustness of the MEMS devices (anti stiction, high-g shock). For the wafer scale bonding of the sensor device and the protective encapsulation a dedicated multi pressure wafer level packaging process is applied using a gold silicon eutectic process at about 400°C. The metallic bond frame induces a hermetic encapsulation of the cavity and the pressure applied during the bond process will persist. Integrated getter films allow cavity pressure levels down to 10^{-6} bar and a pressure ratio within adjacent cavities of up to 1:400. The application range of PSM-X2 platform includes e.g. inertial sensors, micro mirrors or electro-optic deflection devices.

Dual-Layer EpiPolySilicon Process

Recently, Fraunhofer ISIT has developed an innovative process technology for the manufacturing of sophisticated MEMS scanners ($^2\varepsilon$ process). Following the success of the well established surface micromachining technology PSM-X2 for inertial sensors, the $^2\varepsilon$ process is based on structuring two 30 microns thick epitactically grown polysilicon layers.
This allows the realisation of staggered finger combdrives for mirror actuation and detection and the design of suspension.

Metal Surface Micromachining

Metal surface micromachining is an alternative way to build up complete MEMS systems or a part of them. By using mainly electroplating and lithography in combination with PVD, PECVD and etching processes it is possible to fit the requirements for a variety of applications. The low CMOS/ASIC compatible temperature budget makes this process suitable for the monolithical integration of a complete MEMS system. Additional a high flexibility in design and thickness is given.

Application Areas

- Monolithical integration, post-CMOS/ASIC compatible processing
- Electrodes for electrostatic actuation/deflection
- Bondframes for wafer level packaging, eutectic AuSi, AuSn
- Metal wiring
- Bondpads, bumps
- High-Q inductors

INNOVATION CATALOG

ISIT offers its customers various products and services already developed for market introduction. The following table presents a summary of the essential products and services. Beyond that the utilization of patents and licences is included in the service.

Power Electronics	Market	Contact Person
Power electronic systems	Electronic industry	Prof. Holger Kapels + 49 (0) 4821/17-4302 holger.kapels@isit.fraunhofer.de
IC processes and power devices CMOS, PowerMOS, IGBTs Diods	Semiconductor industry IC-users	Prof. Holger Kapels + 49 (0) 4821/17-4302 holger.kapels@isit.fraunhofer.de
Battery management systems	Portable devices subsea vehicles automotive	Dr. Dirk Kähler + 49 (0) 4821/17-4604 dirk.kaehler@isit.fraunhofer.de
Secondary lithium batteries	Mobile electronic equipment, medical applications, stationary storage solutions, automotive, smart cards, labels, tags	Dr. Andreas Würsig +49 (0) 4821/17-4336 andreas.wuersig@isit.fraunhofer.de
Battery test service, electrical parameters, climate impact, reliability, quality	Mobile electronic equipment, medical applications, stationary storage solutions, automotive, smart cards labels, tags	Dr. Andreas Würsig +49 (0) 4821/17-4336 andreas.wuersig@isit.fraunhofer.de

Micro Manufacturing Processes	Market	Contact Person
Chemical-mechanical polishing (CMP), planarization	Semiconductor device manufacturers	Christian Beckhaus + 49 (0) 4821/17-4232 christian.beckhaus@isit.fraunhofer.de
Wafer polishing	Si substrates for device manufacturers	Christian Beckhaus + 49 (0) 4821/17-4232 christian.beckhaus@isit.fraunhofer.de
Single processes and process module development	Semiconductor industry semiconductor equipment manufacturers	Christian Beckhaus + 49 (0) 4821/17-4232 christian.beckhaus@isit.fraunhofer.de
Customer specific processing	Semiconductor industry semiconductor equipment manufacturers	Christian Beckhaus + 49 (0) 4821/17-4232 christian.beckhaus@isit.fraunhofer.de
Quality and reliability of electronic assemblies	Microelectronic and power electronic industry	Dr. Wolfgang Reinert + 49 (0) 4821/17-4216 wolfgang.reinert@isit.fraunhofer.de
Material and damage analysis	Microelectronic and power electronic industry	Dr. Wolfgang Reinert + 49 (0) 4821/17-4216 wolfgang.reinert@isit.fraunhofer.de
Packaging for microsystems, sensors, multichip modules	Microelectronic, sensoric and medical industry	Dr. Wolfgang Reinert + 49 (0) 4821/17-4216 wolfgang.reinert@isit.fraunhofer.de
Wafer level packaging, ultra thin Si packaging and direct chip attach techniques	Microelectronic, sensoric and medical industry, automotive industry	Dr. Wolfgang Reinert + 49 (0) 4821/17-4216 wolfgang.reinert@isit.fraunhofer.de
Design kits WLP	MEMS foundries, fabless design house	Dr. Wolfgang Reinert + 49 (0) 4821/17-4216 wolfgang.reinert@isit.fraunhofer.de
Thermal measurement and simulation	Microelectronic and power electronic industry	Dr. M. H. Poech + 49 (0) 4821/17-4607 max.poech@isit.fraunhofer.de
Application center for process technologies in manufacturing electronic assemblies	Electronic industry	Helge Schimanski +49 (0) 4821/17-4639 helge.schimanski@isit.fraunhofer.de

	Market	Contact Person
Electrodeposition of microstructures	Surface micromachining	Martin Witt + 49 (0) 4821/17-1437 martin.witt@isit.fraunhofer.de
MEMS process development and integration	Electronic industry	Björn Jensen + 49 (0) 4821/17-1434 bjoern.jensen@isit.fraunhofer.de
Beam deflection components for maskless nanolithography	Semiconductor equipment manufacturers	Dr. Klaus Reimer + 49 (0) 4821/17-4233 klaus.reimer@isit.fraunhofer.de
Vacuum wafer bonding technology	Microelectronic, sensoric and medical industry, automotive industry	Dr. Wolfgang Reinert + 49 (0) 4821/17-4216 wolfgang.reinert@isit.fraunhofer.de
Pilot production fabless design house	MEMSfoundries,	Christian Beckhaus + 49 (0) 4821/17-4232 christian.beckhaus@isit.fraunhofer.de

MEMS Applications	Market	Contact Person
Inertial sensors	Motorvehicle technology, navigation systems, measurements	Dr. Klaus Reimer + 49 (0) 4821/17-4233 klaus.reimer@isit.fraunhofer.de
Piezoelectric microsystems	Sensors and actuators	Dr. Dirk Kaden + 49 (0) 4821/17-4606 dirk.kaden@isit.fraunhofer.de
Microoptical scanners and projectors	Consumer and automotive, optical measurement industry, telecommunication	Dr. Ulrich Hofmann + 49 (0) 4821/17-1429 ulrich.hofmann@isit.fraunhofer.de
Flow sensors	Automotive, fuel cells	Dr. Thomas Lisec +49 (0) 4821/17-4512 thomas.lisec@isit.fraunhofer.de
Magnetic field sensors	Electtronic industry	Dr. Fabian Lofink + 49 (0) 4821/17-4227 fabian.lofink@isit.fraunhofer.de
Acoustic MEMS	Consumer electronics	Dr. Fabian Stoppel + 49 (0) 4821/17-1455 fabian.stoppel@isit.fraunhofer.de
RF-MEMS	Telecommunication	Dr. Thomas Lisec + 49 (0) 4821/17-4512 thomas.lisec@isit.fraunhofer.de
MEMS Actuators	Consumer products,c Industrial applications	Dr. Fabian Stoppel + 49 (0) 4821/17-1455 fabian.stoppel@isit.fraunhofer.de
MST design and behavioural modelling and wafer tests	Measurement, automatic control industry	Fabian Stoppel + 49 (0) 4821/17-1455 fabian.stoppel@isit.fraunhofer.de
Electrical biochip technology (proteins, nucleic acids, haptens)	Biotechnology, related electronics microfluidics, environmental analysis, Si-chipprocessing, packaging, chip loading	Dr. Eric Nebling + 49 (0) 4821/17-4312 eric.nebling@isit.fraunhofer.de
Wearable, flexible and hybrid electronics	Electronic industry, medical and sports applications	Dr. Thomas Knieling + 49 (0) 4821/17-4605 thomas.knieling@isit.fraunhofer.de

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 69 institutes and research units. The majority of the 24,500 staff are qualified scientists and engineers, who work with an annual research budget of 2.1 billion euros. Of this sum, 1.9 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 state 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.

International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the 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.

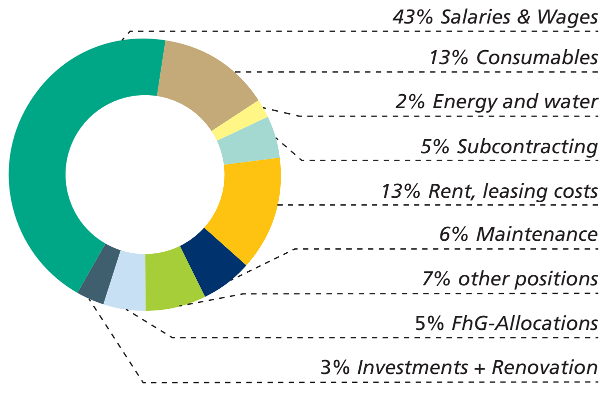
As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the 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.

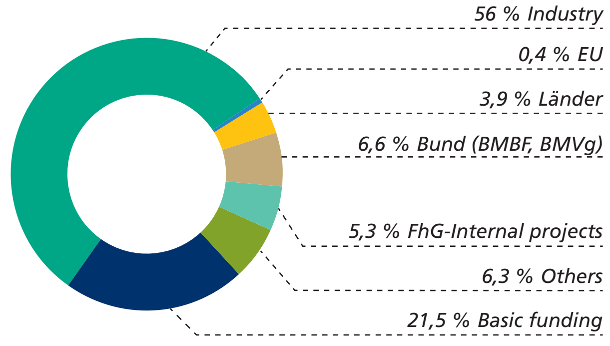
LOCATIONS OF THE RESEARCH FACILITIES

REPRESENTATIVE FIGURES

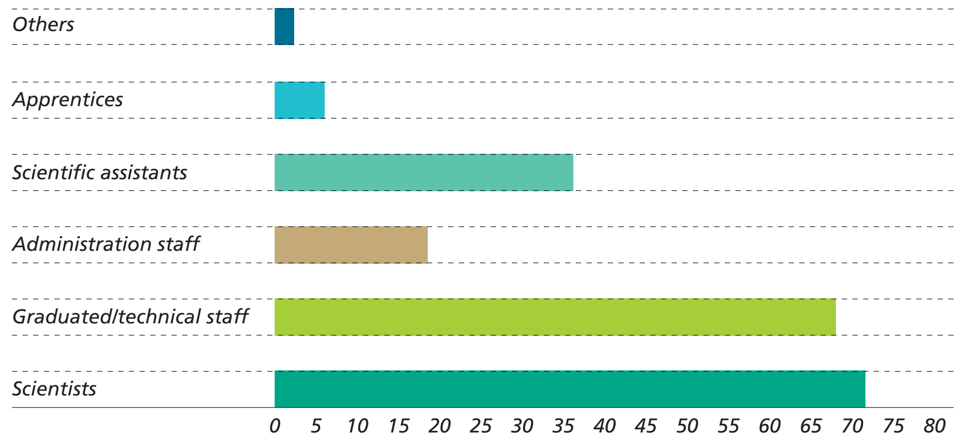
Expenditure
In 2016 the operating expenditure of Fraunhofer ISIT amounted to 25.993,9 T€. Salaries and wages were 11.004,0 T€, material costs and different other running costs were 13.743,5 T€. The institutional budget of capital investment and renovation was 846,4 T€.



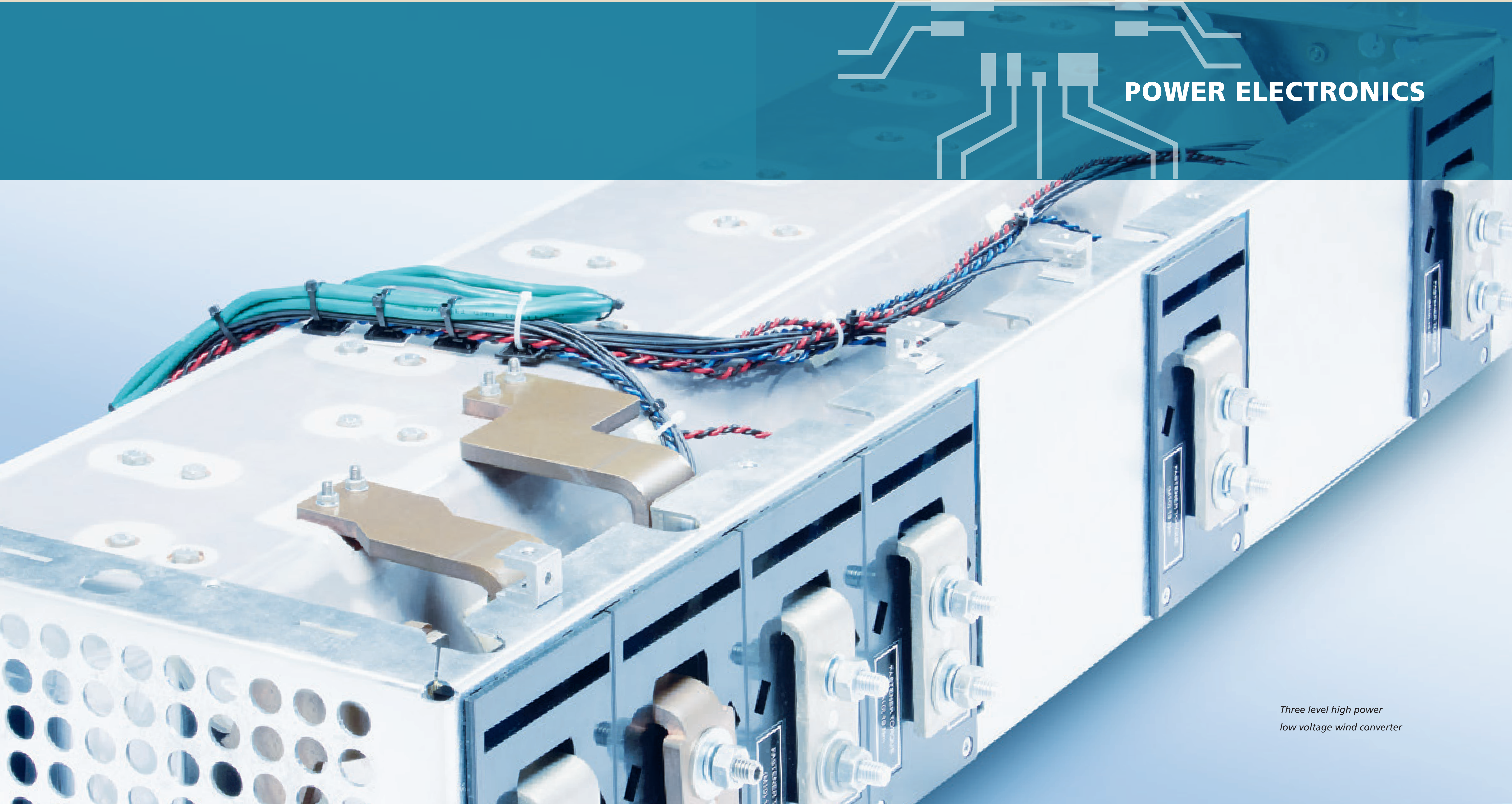
Income
The budget was financed by proceeds of projects of industry/industrial federations/small and medium sized companies amounting to 14.336,4 T€, of government/project sponsors/federal states amounting to 2.672,8 T€ and of European Union/others amounting to 1.711,8 T€. Furthermore there were Fraunhofer-projects about 1.368,8 T€ and basic funding with 5.504,1 T€.



Staff Development
At the end of 2016 the staff consisted of 158 employees. 71 were employed as scientific personnel, 68 as graduated/technical personnel and 19 worked within organisation and administration. The employees were assisted through 36 scientific assistants, 6 apprentices and 2 others.



POWER ELECTRONICS



Three level high power
low voltage wind converter

ONLINE IGBT JUNCTION TEMPERATURE MEASUREMENT BY PARAMETER IDENTIFICATION OF A GREY BOX MODEL

Online temperature measurement is an active field of research. Nevertheless, so far no temperature measurement method was established as defacto standard. It seems to be consensus, that temperature sensitive electrical parameters (TSEP) are most promising for temperature measurement. No consensus exists for which parameter should be used. In this approach the focus is on the internal gate resistance as TSEP.

We use the shape of the curves of the voltages measured in the gate branch. This is done by deriving the transfer function of the equivalent circuit of the gate branch, transforming it into discrete time and using measurement data for parameter identification.

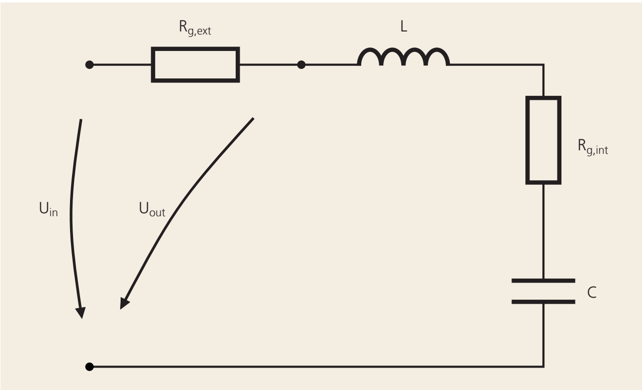


Figure 1: Equivalent circuit of an IGBT gate branch

Equivalent circuit

In the process of switching on an IGBT, the gate branch can be modeled as an RLC equivalent circuit, as given in figure 1, where $R_{g,ext}$ is the external gate resistance of the driver, $R_{g,int}$ and C are the internal gate resistance and the input capacitance of the IGBT and L is the stray inductance. This equivalent circuit is valid as long as there is no load current Ic.

Method

To obtain the temperature of the IGBT, the voltages U_{in} and U_{out} are measured. The voltage U_{in} is used as input to a second order discrete-time transfer function. A simplex algorithm is used to find the parameters minimizing the root mean square (rms) error between simulated and measured output, i.e. a grey box model is used. Note that the output is set to be U_{in}-U_{out}. Figure 2 shows in an example of measured input and output and the time response to the input signal using the parameters that minimize the rms error.

Measurement board and test setup

A measurement board was developed with focus on optimal design with respect to the electrical behavior. EMC aspects were also of great importance. Figure 3 shows the test setup. The electrical measurement data is taken using and oscilloscope and the temperature is measured with a thermographic camera. A heating plate is used to bring the IGBT to a specific temperature.

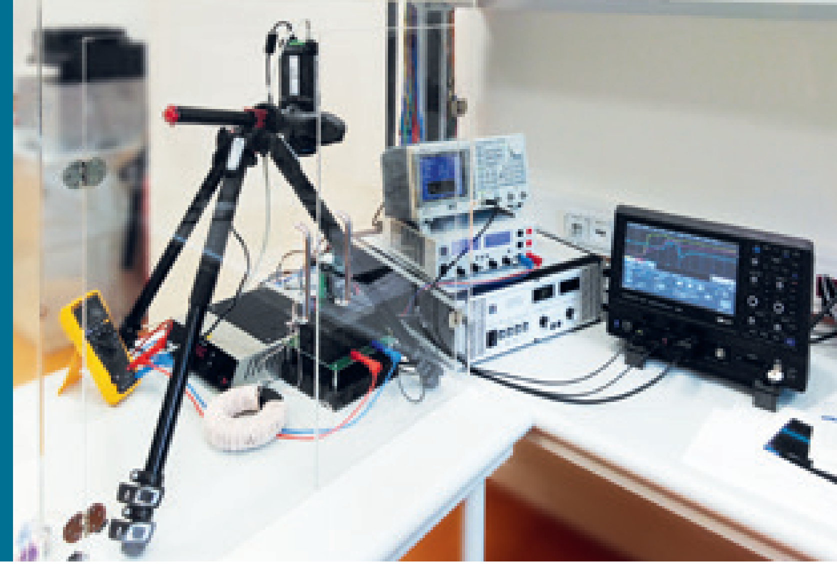
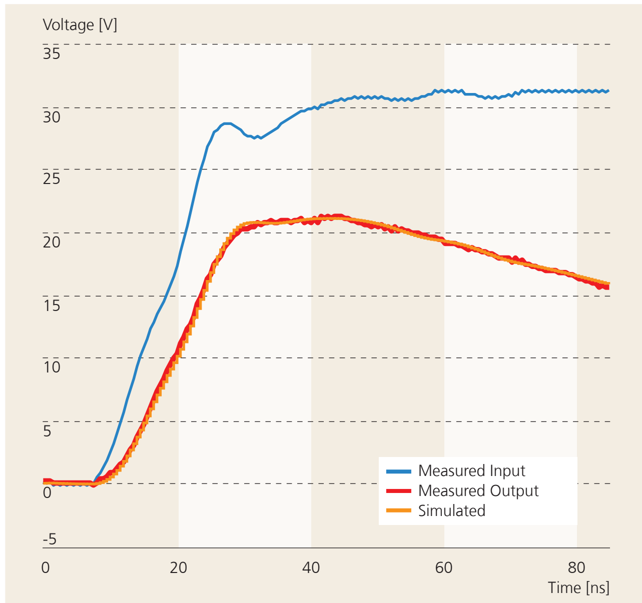


Figure 3: Test setup

Experimental results

The IGBT under investigation was the Infineon IKW40N120H3. A double pulse experiment was performed at 200 V. The maximal load current was 16 A. The parameters of the transfer function were identified and the corresponding internal gate resistance was calculated. Figure 4 shows the identified values of the internal gate resistance over the given temperatures.

Figure 2: Measured input and output voltage and simulated output of the transfer function



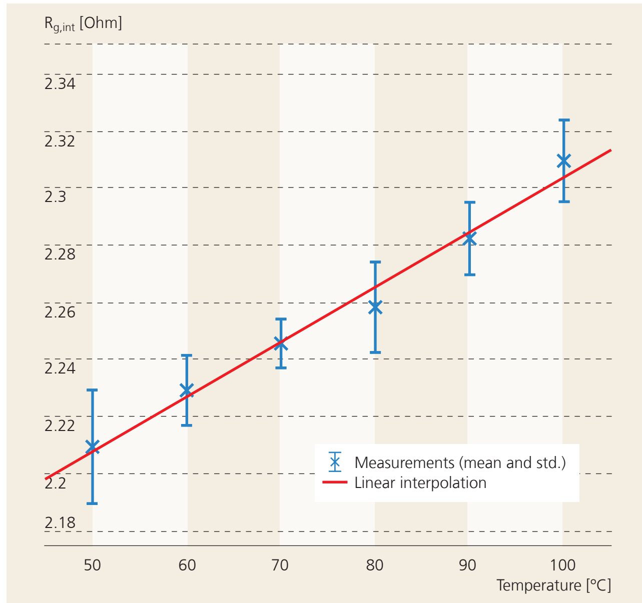
Conclusion

The internal gate resistance is a promising TSEP and can be used for temperature measurement. The advantage over other TSEPs is, that the voltage is not as high as in the load circuit and – as long as measurements are taken before the load current is present – independent of the load. On the other hand the sampling time needs to be quite high.

As a next step we will implement this method on a micro controller, where some steps concerning the sampling rate have to be tackled.

Authors: Dr. Georg Pangalos, Malte Päsler, Prof. Dr. Holger Kapels

Figure 4: Internal gate resistance $R_{g,int}$ over temperature



INTEGRATED CONVERTER FOR MODULAR DISTRIBUTED ELECTRO DRIVES OF HIGH ROTATION SPEED – INMOVE

According to the increasing activities concerning the improvement of electric and hybrid cars, an integrated power electronic converter for a modular drive concept is currently under investigation within the framework of the project InMOVE (integrated converter for modular distributed electric drives of high rotation speed).

The idea behind the modular drive concept is to combine existing gear box designs with small and medium drive motors. Depending on the vehicle class, an electric car then will be equipped with one or more modular drive units, e.g. with a power of about 40 kW each. In this way, the total drive power depends on the number of modular drives and can thus amount to 80 kW or 120 kW for two or three drives, respectively. An example is shown in figure 1, where two modular drives are mounted on a gear box.

The modular power unit includes all the components required for an independent drive. The only external supply connections comprise the 90°C cooling water, the DC battery (560 V to 800 V) and the electronic engine control.
Finally, the motor power is transferred to the motor axis which is connected to the gear box appropriately.

The modular drive unit allows the development of a customized, inexpensive, efficient and compact drive topology of plug-in vehicles. In order to enable the adaptation of the modular drive to various gear boxes, the drive unit must be designed as a slim and fast rotating electric motor with an integrated power converter. Figure 2 shows the combination of the power converter and the electric motor with all supply connections. The power converter inverts the battery direct current into a rotary current which drives the electric motor.

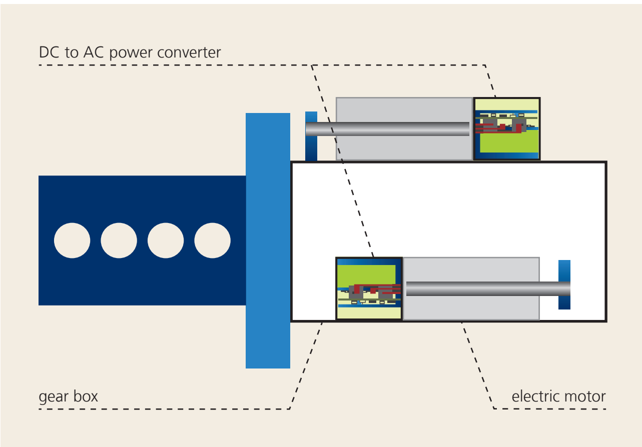


Figure 1: Modular drive concept showing two modular drive units connected to a gear box

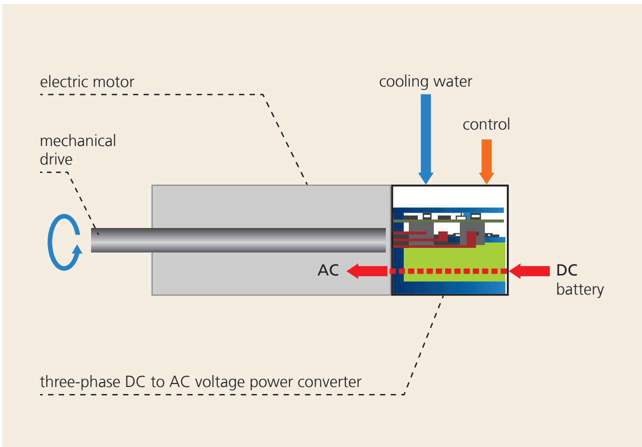


Figure 2: Modular drive unit with 40 kW power

During inversion from DC to AC current the electronic components generate a permanent power loss that must be dissipated by cooling water. The maximum allowed junction temperature for both, the power transistors and diodes, is 175°C. The cooling water temperature of the car typically is at 90°C, thus an effective cooling of the power unit is difficult. Either a great effort for an extra cooling water system with lower supply temperature is necessary, or the power loss of the electronic power converter needs to be reduced.

The goal of the InMOVE project is to reach a power density of 100 kW/ltr at 70 kW peak power for each modular drive unit. The diameter of the power converter unit equals the diameter of the motor itself, since the converter is directly flanged to the electric motor.
In consequence all components of the power unit need to fit into a small volume, including the DC link capacitor, the driver electronics, and the power modules as well as the busbar, the heat sink and all necessary connections to the motor. This work requires the different knowledge and experience of the project partners as well as modern computer based software tools for layout and simulation.

For the power converter, modern trench Field-Stop IGBTs are used, which are designed for 1200 V and a nominal current of 200 A. The IGBTs are fabricated jointly with Vishay Siliconix Itzehoe within the InMOVE project.
For the IGBT optimization, a basic trench cell architecture was used as shown in figure 3. A top view of the front side of one IGBT chip is given in figure 4. The device is coated with a Ni/Au surface layer which is necessary for front side sintering.

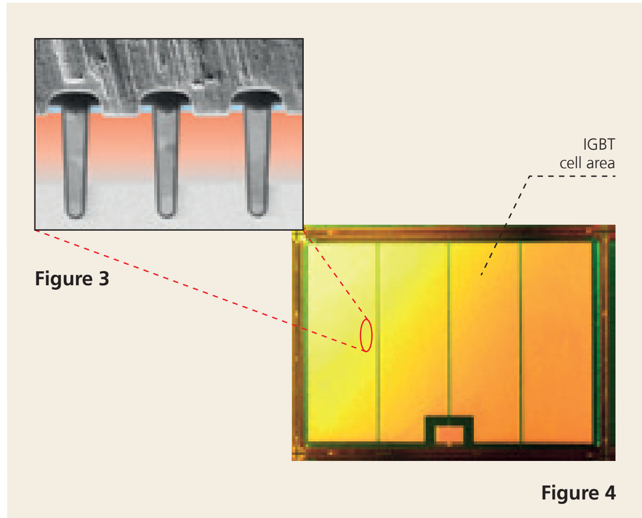


Figure 3: Cross section of a standard trench IGBT

Figure 4: Top view on a field stop trench IGBT, 1200 V, 200 A, 16 X 12 mm², thickness of 135 µm

A great effort is taken to reduce the IGBT heating which is caused by the power losses during on-state and switching. Depending on the switching frequency, either the on-state losses or the switching losses will dominate the heat generation in the device. For the drive unit, a frequency of 13,5 kHz was defined by the project consortium.

This is rather a high value, so the switching losses will dominate. The IGBT features are strongly determined by the IGBT trench cell architecture and the selected technological parameters for the collector design. Basic IGBT characteristics, like the turn-off losses (E_{off}) and the on-state voltage (V_{CEsat}), are typically displayed in a trade-off curve as shown in Fig. 5. A low on-state voltage correlates with high turn-off losses and vice versa. For the current power modules fast switching IGBTs have been produced on base of a specific parameter set with values for E_{off} and V_{CEsat}, as displayed as square (■) in figure 5.

Within a further technological approach, the IGBT cell architecture is strongly modified in order to reduce the overall gate capacity. The hole current in this case is concentrated next to active trenches and causes an enhanced injection of electrons ("Injection Enhancement"), which will reduce the on-state losses. The number of active gates is periodically reduced by insulating the gate trenches from the IGBT gate contact. Thus the gate capacity is effectively reduced, which enables a faster switching of the IGBT with lower energy loss. Both measures will reduce the heating of the components and will shift the trade-off curve to lower values. According to an initial estimation, the total losses of the IGBTs should be reduced by 20–30 % compared to standard products.

Author: Hans-Jürgen Schliwinski

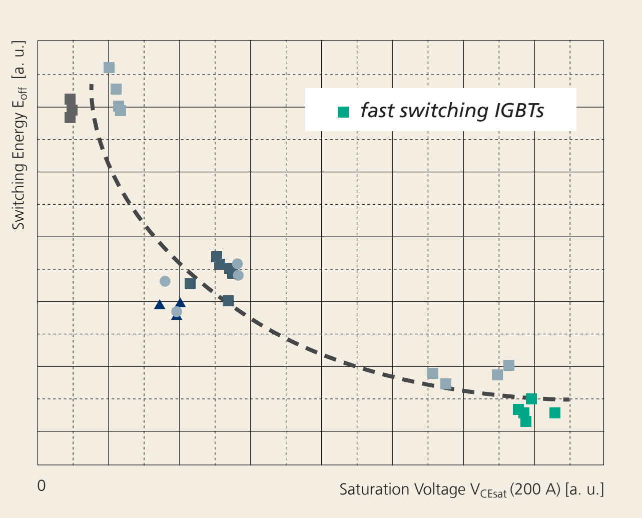


Figure 5: Trade-Off curve for different application specific 200 A Field-Stop IGBTs

Projekt-Name

InMOVE

Integrierte Umrichter für modular verteilte Elektroantriebe hoher Drehzahl
Integrated converter for modular distributed electro drives of high rotation speed

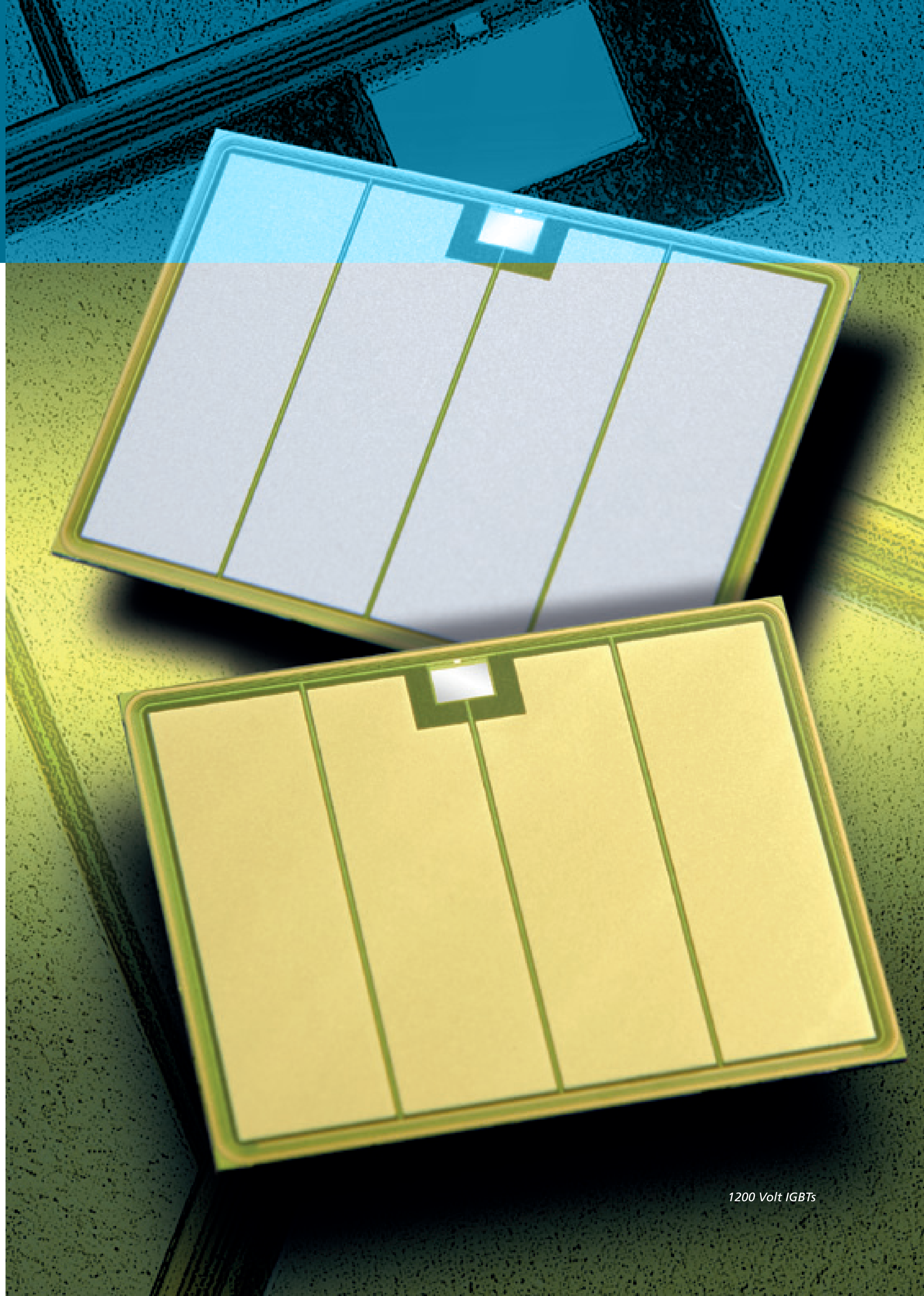
Gefördert durch:

Bundesministerium für Wirtschaft und Technologie

aufgrund eines Beschlusses des Deutschen Bundestages

BMWi-Ausschreibung ‚ATEM3'
Koordinator: Volkswagen AG
Projektleiter ISIT: Hans-Jürgen Schliwinski
Stellvertreter ISIT: Dr. Jörn Hinz

Partner: VOLKSWAGEN, FTCAP, Danfoss, Reese+Thies, VISHAY, Fachhochschule Kiel University of Applied Sciences, Fraunhofer ISIT



1200 Volt IGBTs

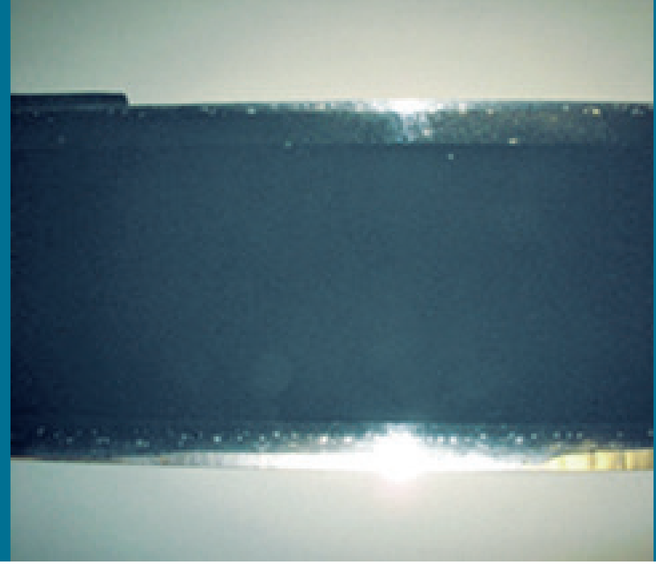


Figure 2: Electrode (cathode) prepared with a water based binder system

LITHIUM-SULPHUR BATTERIES

The increased electrification of the transport sector, the "electromobility" revolution, is one of the major driving forces for energy storage breakthroughs. Current rechargeable Li-ion batteries for electric vehicles (EV) are capable to deliver around 180 Wh/kg energy density on the cell level and 120 Wh/kg on the battery pack level, while typical consumption of a liter of gasoline produces 2500 Wh of useful work. So there is still a factor of 15 between the energy delivered by one liter of gasoline and 1 kg of battery (e.g. the autonomy of the car with similar weight that is driven by batteries is between 5-10 times shorter than with gasoline). Hence, if we want to achieve or even approach the goal of a 500 km driving range using battery powered vehicles in short term, Lithium-Sulphur batteries are the closest battery technology for fulfilling this expectation. The principle of Lithium-Sulphur battery technology has been known for several decades, and one of the pioneering works in this field has been published by Prof. Peled in 1989. In theory, Li-S battery can fulfil all the requirements of the intelligent vehicle battery system since it possesses a high gravimetric (low weight) as well a high volumetric (small size) energy density. In addition, it can be produced as a flexible, environment-friendly and cost effective cell and it offers a safe and a reliable operation. Elemental Sulphur as positive electrode material in the combination with Lithium metal as negative electrode material can be considered as an attractive rechargeable cell, with a possibility of giving, by virtue of i) the low equivalent weight of Lithium and of Sulphur and ii) an average 2.1V redox voltage, theoretical energy values approaching 2500Wh/kg (or 2800Wh/l) assuming reaction to Li_2S.

A simplified picture of Li-S battery operation is shown in Figure 1. The Li-S system mainly consists of a Sulphur cathode (or positive electrode) comprising elemental Sulphur dispersed in a Carbon medium, a binder, a porous separator, a non-aqueous multi-component electrolyte, and a Lithium metal anode. During the first discharge, elemental Sulphur (S8) accepts electrons leading to equilibrium of various soluble polysulphides (long-, mid- and short-chain) and finally at the end of the discharge plateau insoluble Li_2S is formed.
Due to a high concentration gradient of polysulphides in the electrolyte, polysulphides are prone to diffuse away from the cathode composite to the separator and further to the metallic Lithium, where they can react with metallic Lithium and form shorter chain polysulphides or even precipitate to the Lithium surface as insoluble short chain polysulphides or as Li_2S. This so called polysulphide shuttle is responsible for lower coulombic efficiency and partially for the capacity loss during cycling. Within the EU Project HELIS, which was started in 2015, Fraunhofer ISIT developed new electrode formulations using water based binder systems (Figure 2). This allows for the use of an environmentally friendly production process in comparison to the otherwise customary use of the solvent NMP. Electrochemical test cells have been assembled by project partners. They show a good performance and cycle stability of the electrodes (Figure 3). Within the project, ISIT is aiming to produce cells based on the pouch technology with an energy density of 500 Wh/kg.

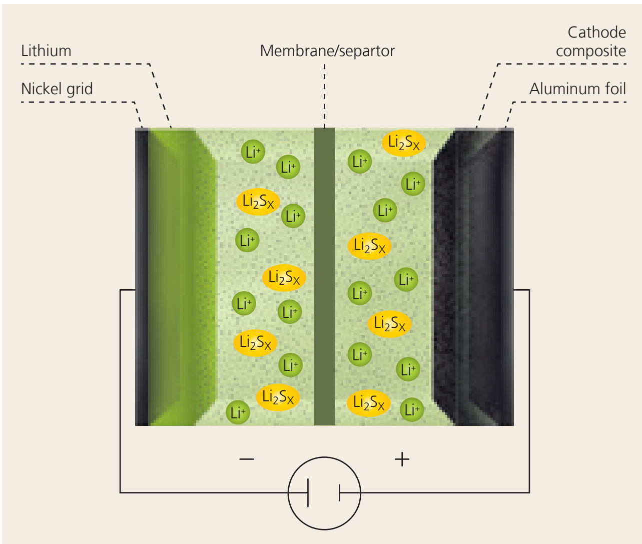


Figure 1: Schematic view of Li-S cell with polysulphide shuttle mechanism

Magnesium-Sulphur batteries

Rechargeable Magnesium Sulphur batteries (Mg/S) are promising candidates for electrochemical energy storage due to their high theoretical capacity (1.671 mAh/g or 3.832 mAh/cm^{-3}), their operational safety and low raw material costs. The overall electrochemical reaction is reversible and can by represented by the following equation:
1/8 S8 + Mg ⊏ MgS
Using Magnesium instead of Lithium as an anode material, one can consider a safer electrode because it does not form dendrites. One of the biggest challenges of the past – a suitable electrolyte which allows an efficient Mg-ion transfer and a reversible deposition of Mg – is hence resolved.
Within the scope of the "MagS" project, Fraunhofer ISIT explores the principal aspects of cell manufacturing of rechargeable Magnesium Sulphur batteries respectively the scale-up of the laboratory methods. Therefore, the new materials such as Sulphur-Carbon composites developed by project partners will be processed in a production-related environment. This covers the adaption of slurry recipes as well was complementary techniques on mixing, dispersing and coating to receive mechanically stable, processable Sulphur cathodes. To fabricate a fully functional Mg anode is another objective of this project.

Afterwards, these electrodes will be assembled to pouch cells. Key aspects of the cell assembly are the handling of components, stacking and joining technologies. At predefined intermediate steps points the individual process steps are verified by corresponding physical and electrochemical procedures that allow an iterative optimization of processes and (raw) materials as well.

Author: Andreas Würsig

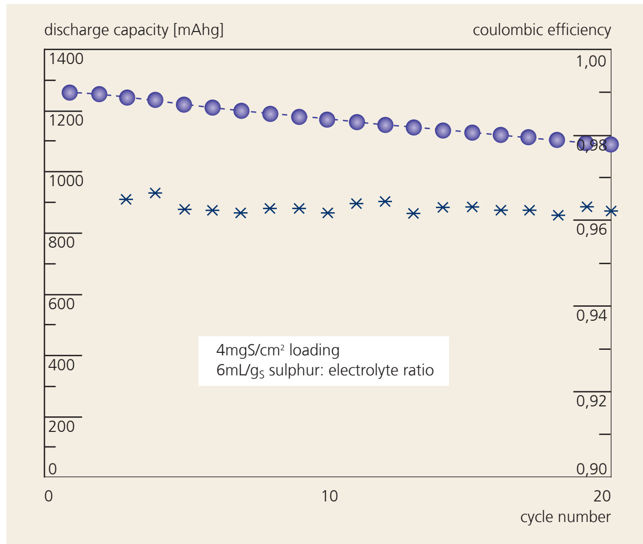
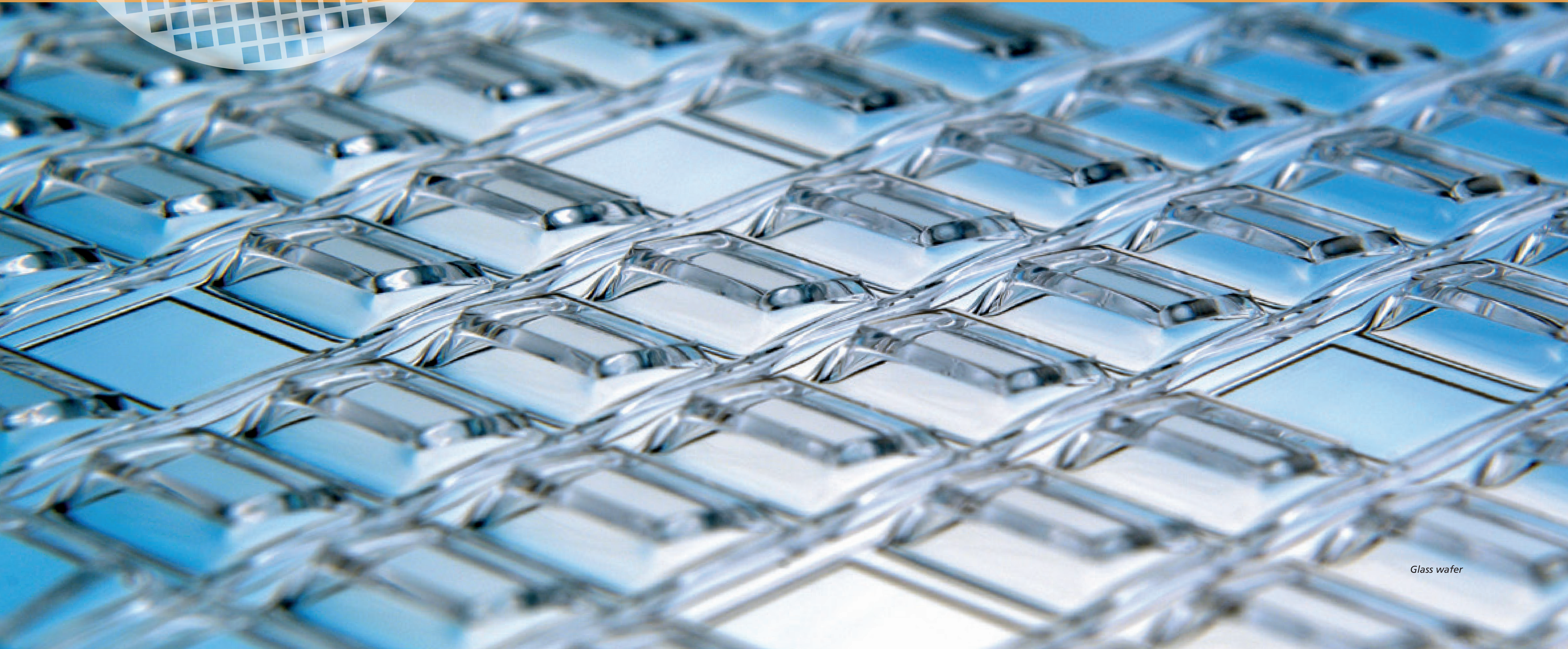


Figure 3: Cycle stability of Li-S cells using a cathode developed by Fraunhofer ISIT

MICRO MANUFACTURING PROCESSES



Glass wafer

WAFERLEVEL 3D-INTEGRATION OF IR-SENSOR TECHNOLOGIES

Any object in our surrounding radiates heat as an electromagnetic wave - similar to light, but invisible to our eyes. Various physical effects, however, allow us to detect and visualize heat radiation. In particular, microbolometer and thermopile detectors are currently spreading fast because they do not require any cooling. This makes them particularly suitable for mass markets. Possible applications comprise e.g. the improvement of energy efficiency in processes and equipment, person detection and medical temperature measurement.

Two major obstacles thus still exist: First, application business cases need to be established that, from an economical viewpoint, justify an entrance into high-volume manufacturing of detector chips on the wafer level. This development is currently taking place, since person counting and gesture recognition are easier to realize in the IR domain than with CMOS cameras. Second, the optical system is still too expensive: Lenses for the far-infrared domain (around 10 µm center wavelength) and their assembly contribute between 25…75 % to the production cost for an infrared detector system. Hybrid integration concepts therefore have limited potential for cost reduction.

Much higher chances lie in wafer level optics, because integration and alignment on the wafer level are executed for several thousand systems at once. In the BMBF-funded project „Waferlevel 3D-Integration of IR Sensor Technologies“ (WIN-IT, Förderkennzeichen 13N12626), modular and versatile technologies were developed that are suitable to reduce the cost of small infrared detector systems. The project was a successful cooperation with the fabless microelectronics supplier Melexis and the two X-FAB MEMS foundries in Erfurt and Itzehoe.

Within the project, ISIT’s targets were to develop a bonding process for producing small thermopile detectors in high volumes, as well as building a basic platform for the integration of IR optics into wafer level packages. The sensor itself was designed by Melexis and manufactured in X-FAB’s CMOS foundry in Dresden. The X-FAB MEMS Foundry Itzehoe GmbH was responsible for the production related aspects of the process integration, while the X-FAB Semiconductor Foundries AG in Erfurt studied the feasibility of manufacturing hyper spectral IR filters using materials and processes that are available in a CMOS process.

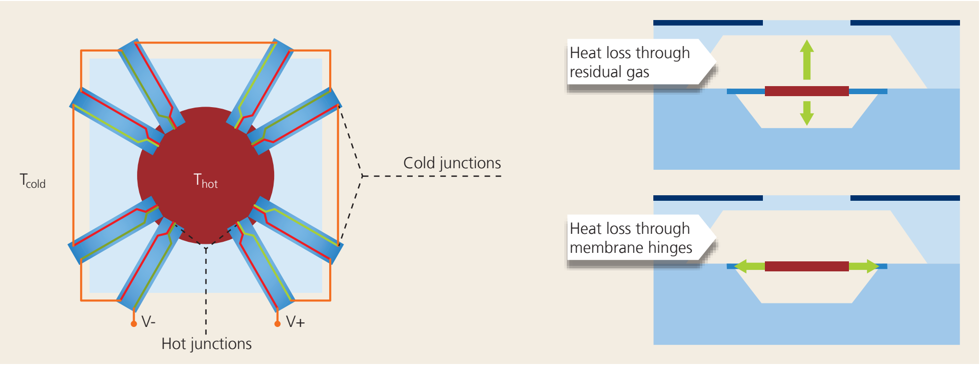


Figure 1: Principle of a thermopile detector and heat loss mechanisms that affect the sensitivity

Together, the partners developed a thermopile sensor architecture including wafer level packaging that will clearly outperform current commercially available detectors. As shown in Figures 1 and 2, thermopiles are formed by coupled p-n semiconductor junctions. ”Hot junctions” are placed on a thin suspended membrane, ”cold junctions” are thermally connected to the bulk chip. Incoming heat radiation heats up the membrane, which generates a temperature gradient towards the bulk. As a consequence of the Seebeck effect, a voltage can be measured across the junctions that is correlated with the temperature of objects within the field of view (FOV).

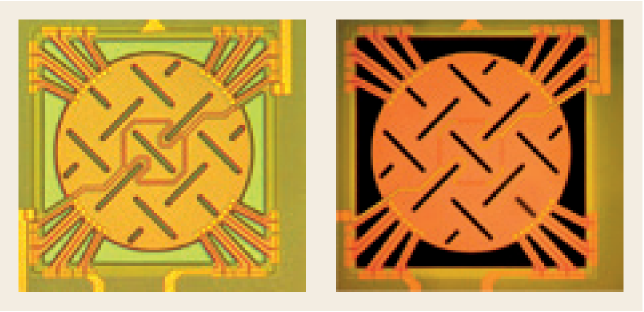


Figure 2: Thermopile pixel with a diameter of approx. 350 µm before and after membrane release etch. The connector line belongs to an integrated Pirani sensor to assess the vacuum level.

Through optimized bonding technology, a high vacuum level was realized in the tiny sensor cavity that strongly reduced heat dissipation from the detector element. Melexis was able to adapt the membrane dimensions to a cavity pressure below 0.1 mbar. An aperture was designed into the cap wafer to obtain a narrow FOV and to eliminate stray light. The Titanium used to form the aperture layer additionally has an important gettering effect on residual gas that was studied in detail (Figures 3–5).

Integrating anti-reflection coatings (ARC) effectively doubles the optical efficiency: Although Silicon has a good IR transmittance, its large refractive index (around 3.4) leads to

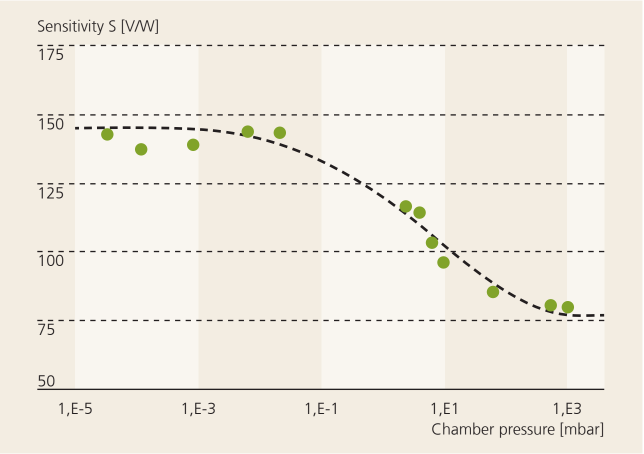
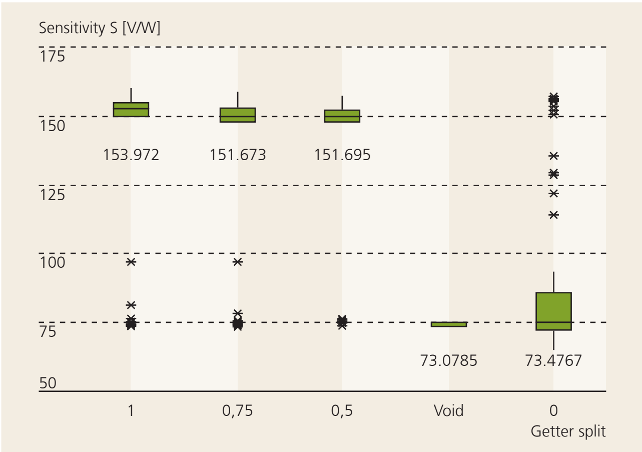


Figure 3: Pirani measurements under vacuum indicate the pixel voltage output as a function of the applied heating power. The detectable vacuum range depends on the pixel design; here the threshold is 1 mbar.



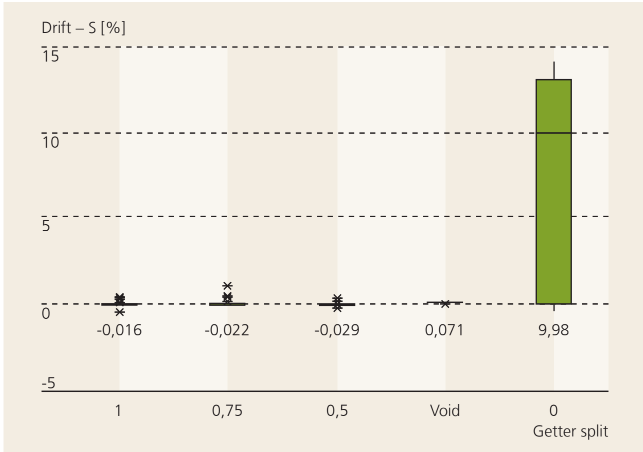


Figure 4: The gettering effect of the Titanium aperture was studied on 3000 dies from 5 wafers with different getter area. In the box plot, all getter shapes have a narrow standard deviation of the Pirani sensitivity while the getter-free package is unable to maintain the vacuum.

Figure 5: The evolution of cavity pressure in an accelerated 120 hour aging at 150°C was characterized by monitoring the sensitivity drift. Again, the Titanium layer reveals to be an effective means to stabilize the cavity pressure.

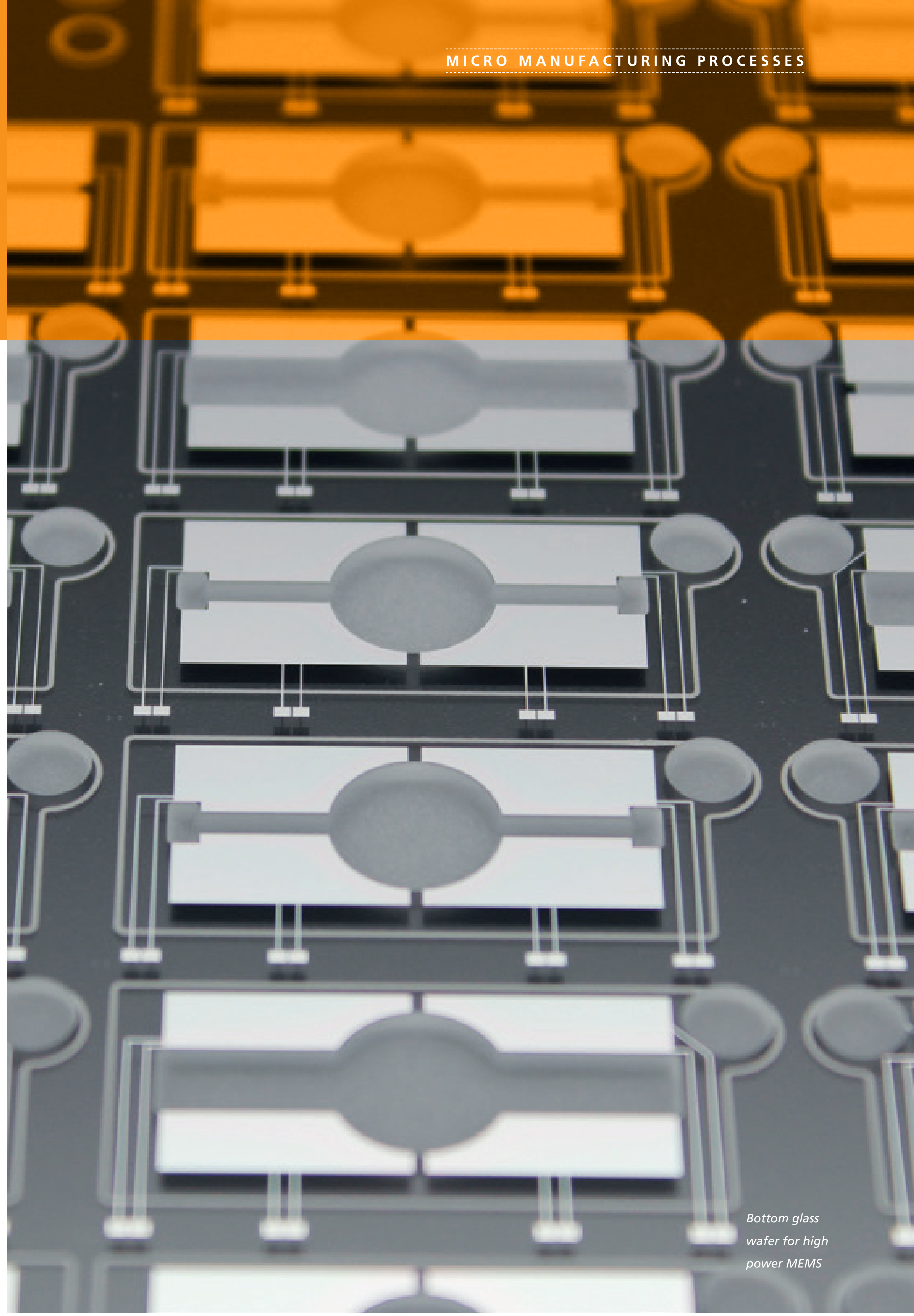
high reflective losses, which makes ARC layers a must. The use of a binary diffractive lens to further improve the optical gain was considered, yet simulations brought evidence that, with the given geometrical and technological constraints, this approach would rather generate stray light than concentrate incoming radiation on the detector element.

ISIT is currently developing an innovative alternative to implement refractive spherical lenses in wafer level packages that promises excellent optical properties for this application.

Conclusion

The WIN-IT project was a successful start into IR sensor technology development with X-FAB and Melexis. ISIT is currently developing a competence portfolio for packaging and characterization of IR optical systems that will allow the partners to follow a common roadmap of technologies and applications for the coming 10 years.

Authors: Norman Marenco, Amit Kulkarni



Bottom glass wafer for high power MEMS

ANALYSIS OF ROOT CAUSES FOR FIRE DAMAGES IN ELECTRONICS

A permanent threat to electronics designers and technologists is the risk that a printed circuit board might be the cause of a fire incident. While such risks are obvious for power electronics, also small mobile devices with seemingly low energy budget need to be considered since accumulators are capable of providing high currents and can generate considerable heat in case of malfunction. Analyzing such failures is one of the regular tasks in our quality and reliability (QZ) team.

Typically known root causes are damaged insulation, loose contacts and high contact resistance, leading to excessive heat generation or overloads on electrical leads and connections. The following case selection from our analysis work will illustrate how ESD damage, overloads and material fatigue by corrosion and contamination can become causes for a fire as well.

Damage analysis and equipment at ISIT: Our damage analysis usually starts with a visual inspection. The broken device is carefully decomposed. After cleaning the board and removing surface layers one by one, first damages can be uncovered (Figure 1). Alternatively, 2D (Figure 2) or 3D X-ray analysis and scanning acoustic microscopy are available.

As soon as a defect is localized, an in-depth analysis can be performed. Metallographic cross sections through circuit boards and silicon dies are prepared by sawing, followed by ultra-fine mechanical or ion polishing. If the defective component is a silicon chip, the packaging epoxy can be safely removed by chemical etching (Figure 3), using the "decapsulator" equipment. For a profound chip analysis, a focused ion beam (FIB) equipment is available. Surfaces are analyzed through classical optical microscopy and high resolution confocal laser scan microscopy. Small samples can be examined in the scanning electron microscope, including EDX spectrography for element analysis or compound inspection.

The following sections explain details about three predominant reasons for fire damage on electronic boards: Electrostatic discharge, electrical overload and corrosion.

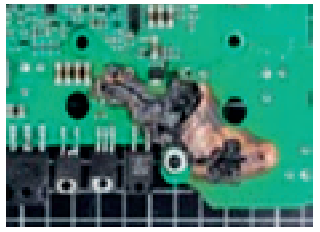


Figure 1: Photograph of an assembled board with a fire-damaged area in the lower right

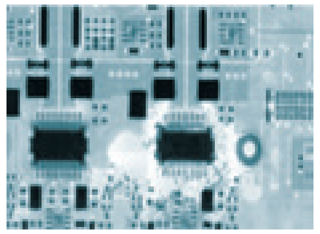


Figure 2: 2D X-ray analysis of a locally burnt board (white area)

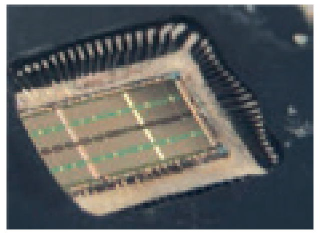


Figure 3: An IC package is etched open for a bond wire inspection

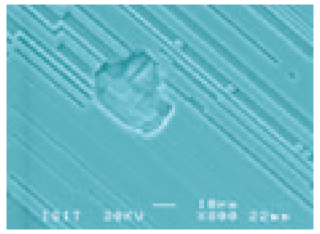


Figure 4: SEM photograph of locally destroyed conductive trace by a sudden current pulse

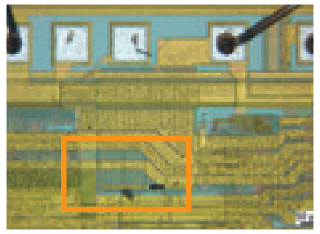


Figure 5: EOS damage, overview with light microscopy (50x)

Figure 6: Local damage inspection with 3D laser scanning microscopy

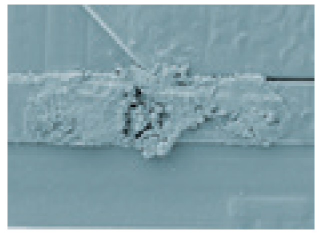


Figure 7: Local damage inspection with SEM. Obviously the conductor is molten

Electrostatic discharge (ESD) is one of the most frequent failures, particularly in semiconductor ICs. Mostly it is caused by a large potential difference across an electrically insulating material. Figure 4 shows how a current pulse interrupted the conductor tracks of a silicon chip like in a fuse.
In extreme cases, a discharge can generate a spark and thus cause a fire in the presence of combustible liquids, gases or even dust (for example industrial solvents, gas installations, coal mines).

Usually, electrostatic charge is accumulated by friction. When the potential exceeds the dielectric breakdown voltage at the weakest point, a very short electric pulse occurs. Electrostatic discharge becomes noticeable at approximately 3000 V, yet many devices only withstand voltages of 5...30 V. It is therefore difficult to maintain the awareness of operating personnel. In production environments, measures have to be taken that reliably prevent uncontrolled electrostatic discharge. Increased damage rates are frequently observed in winter, because the discharge voltage is higher in dry air.

Electrostatic damage in microelectronic components particularly appears in circuits for high-frequency applications, in diode lasers, field-effect transistors and light-emitting diodes, because their technologies have limited design options to implement on-chip protection structures.

Electrical overloads (EOS) occur when electrical energy is unintentionally supplied in the application environment.
As an example, EOS faults in automotive applications can result from inductive crosstalk in the wiring harness, but also from using external supply cables during repair or inspection: Long cables between the vehicle and the power supply can attain a high inductivity. Current transients therefore lead to potentially destructive voltage thresholds when plugging or unplugging devices under load or when losing the ground connection.

Figures 5 to 7 show an example of EOS damage to a conductor trace in a high-performance chip with different inspection methods.

Figure 8: Damage of a silicon power transistor (left) with partial delamination (right) after EOS

EOS damages can also be noticed in p/n-junctions, e.g. in transistors or diodes, and cause local melting of the silicon. These molten volumes are less absorptive to X-rays than the surrounding pure crystalline Silicon. Figure 8 shows an example: After X-ray inspection, the chip package was opened by wet etching. A visual microscope inspection of the cross section revealed a massive overload damage.

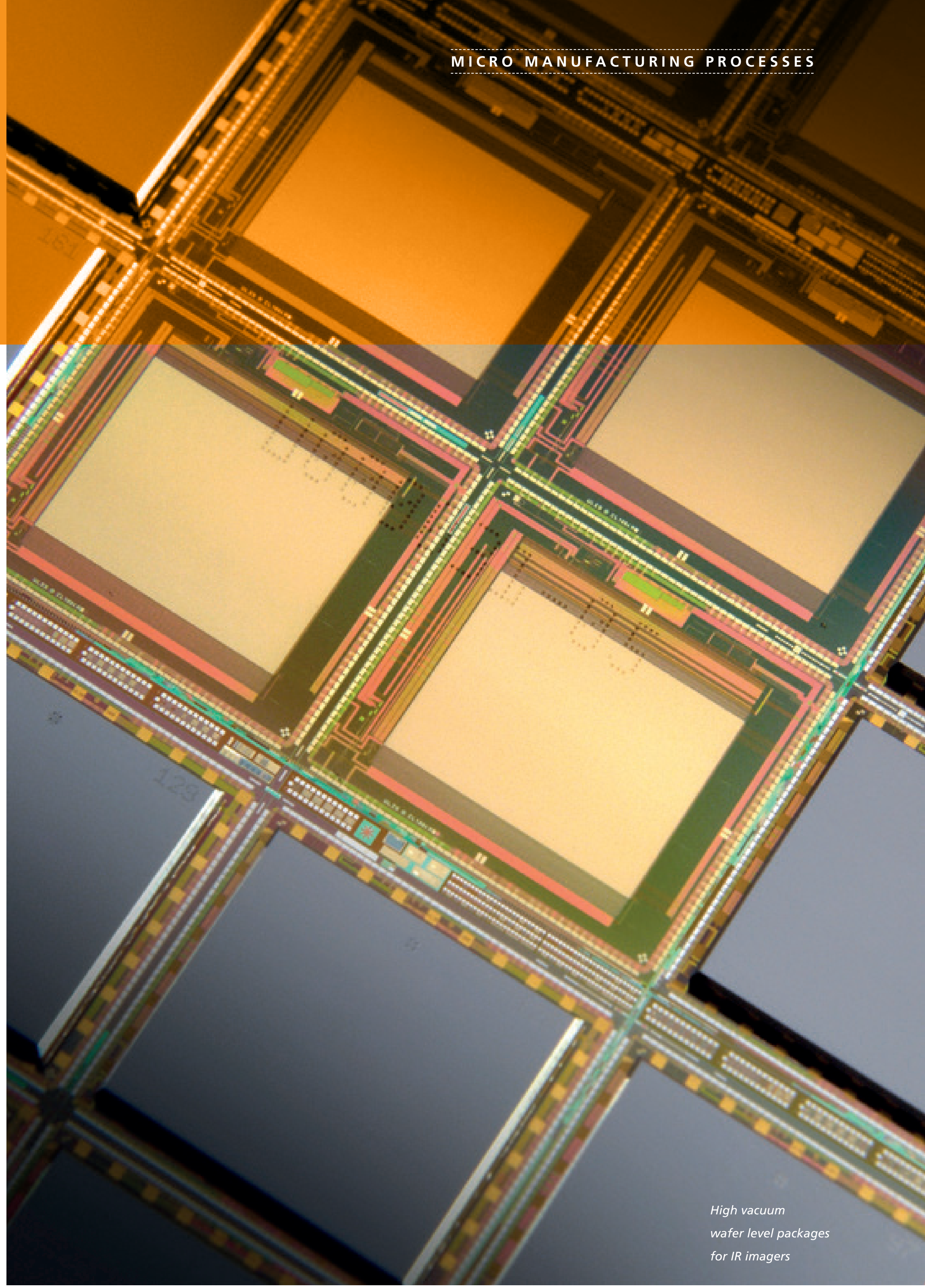
But what are typical factors causing such damages?
A power MOS transistor effectively consists of many small individual transistor elements. In the event of overvoltage, the weakest of them fails, i.e. its resistance decreases rapidly and the current flows locally through this single cell.
The resulting temperature increase can melt the silicon or induce thermomechanical stress that breaks the chip.

*Figure 9:
Burnt track on PCB
after corrosion*

Since damage of the semiconductor generally leads to further local heating of the silicon, a thermal runaway is usually inevitable. Very often, a melting funnel can be observed that appears to be a precursor of complete component destruction. Considering that the melting point of silicon is 1460°C, it is evident that such an incident can become the cause for a fire.

Corrosion: Another failure cause may be a faulty solder stop layer. The presence of pinholes in this layer allows humidity to penetrate and to cause local corrosion of the conductive traces. Two mechanisms lead to further degradation:
First, the conductor width diminishes and its current carrying capacity is reduced. Second, the dissolved copper builds an electrical connection between the two originally isolated potentials. As leakage currents become more significant, the local temperature increases and degrades the organic epoxy material of the circuit board. A chain reaction arises when the epoxy is carbonized, because more and more carbon is produced. After some time, the track is burnt (Figure 9).
To reduce the hazard risk, circuit board material like FR4 usually contains flame retardant additives.

Authors: Dr. Thomas Knieling, Katja Reiter



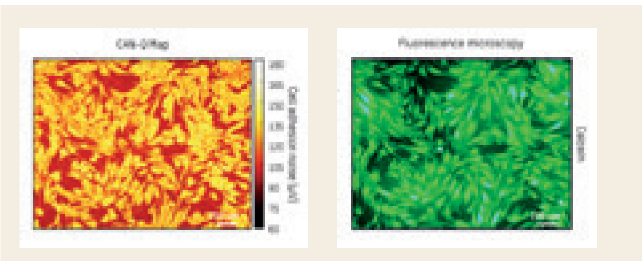
*High vacuum
wafer level packages
for IR imagers*

PILOT MANUFACTURING OF A CELL IMAGING CHIP

The German startup Venneos GmbH was founded in 2014 with the idea to commercialize an innovative cell analysis technology called "CAN (Cell Adhesion Noise) Spectroscopy". The concept is based on a silicon chip that is used as a substrate to cultivate cells in a liquid medium. An array of almost 100,000 tiny measuring pixels on the chip is capable of detecting small fluctuations in in the local electrical field on the chip surface (figure 1). As the cell culture evolves, the images allow to monitor phenotypic cellular behavior such as migration, proliferation, cell death and others.

ISIT was requested to develop a biocompatible chip-on-board assembly process flow for the Venneos chip cartridge that could be transferred into a pilot production. With its industrial bare die assembly equipment and processes, ISIT is capable and specially trained to handle delicate MEMS devices, as well as performing packaging related wafer conditioning, e.g. thinning, dicing and handling with different protective tapes to reduce possible impacts on sensitive chip surfaces.

Figure 1: Comparison of the CAN-Q chip output with fluorescence microscopy (© Venneos GmbH)



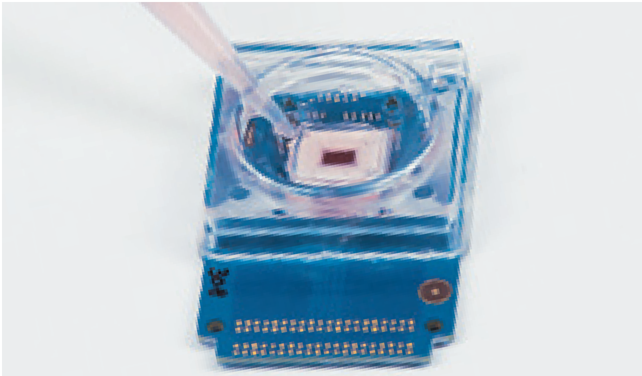


Figure 2: A precision molded second plastic cap with a fluidic window opening protects the sensitive chip area and defines a cell cultivation well

The particular assembly task was extraordinary in the sense that the chip's electrical contacts for wire bonding are located very close to the fluidic interface and sensitive pixel electrodes are exposed in the center of the chip. In a standard chip-on-board assembly, one would use a glob top or dam & fill technique to cover the wire bonds. However, it quickly became obvious that uncontrolled material flow would easily contaminate the sensitive chip surface, affecting seriously the production yield.

ISIT and Venneos solved the problem by using a precision molded plastic cap with a fluidic window opening and integrated seal frames (figure 2). This cap is mounted on the chip immediately after die attach and wire bonding.

In a feasibility phase, ISIT tested different biocompatible adhesives for their dispensing and sealing properties in combination with a cavity filling polymer. A seal frame is dispensed around the sensitive field imaging area, requiring a dedicated high-aspect-ratio dispensing process to compensate for geometrical tolerances of the plastic cap. Extensive tests by Venneos showed that the selected 1K silicone adhesive has minimum effect on the cell physiology.

With a detailed specification of the assembly procedure and bill of materials, a pilot manufacturing of the electrical field imaging chip cartridge was started. Possible yield affecting topics were tracked and appropriate measures were defined to stabilize the yield on a high level. Transportation issues of the cartridges were equally taken into account. All observations and engineering changes are constantly tracked through a quality management system.

The Venneos project is an example for running pilot manufacturing projects at ISIT that aim for delivering functional samples into niche markets, supporting market entries with new products or handling very delicate bare dies in assembly operations. Our customers' advantage is a direct interaction with our engineering team to get their ideas realized, without the need for a large upfront invest in machines and process technology.

Author: Dr. Wolfgang Reinert

Figure 3: Cartridge module boards after die attach at ISIT

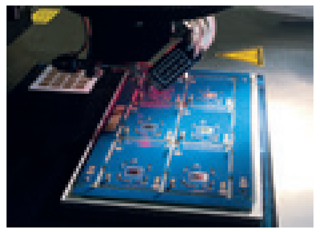


Figure 4: Wire-bonding of the cartridge modules

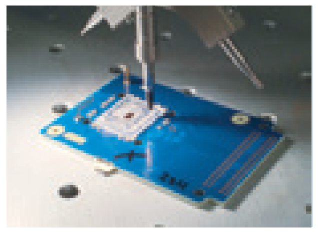


Figure 5: The first plastic cap with its fluidic window is aligned and placed above the sensor chip

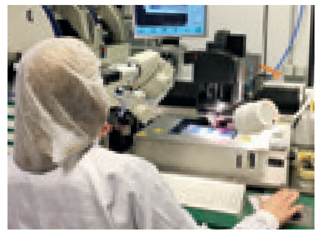


Figure 6: Full automatic wire bonding on panel level

AUTOMATED DAISY CHAIN MEASUREMENTS

The assembly of electronic chips, like application specific integrated circuits (ASIC) or MEMS, often requires the handling of bare dies. Electrical connections can be realized either by wire bonding or flip chip bonding. In case of flip-chip bonding, different methods can be applied like soldering, stud bump bonding, and anisotropic conductive adhesive. For each of these processes, a huge variety of materials is available on the market. Selecting the right one for an application usually requires experiments with different materials and process parameters.

Performing these process optimizations with functional chips would be costly and yield only limited information about the process capability. Therefore, ISIT offers a variety of dummy chips specifically designed for the testing of chip to board interconnects. These components are mechanically very similar to a functional device, but they carry a simple electrical wiring layer that just directly connects pairs of contacts to each other. Combined with a corresponding wiring scheme on the printed circuit board (PCB), a daisy chain connection is formed that can be measured very easily.

Besides custom specific solutions, Fraunhofer ISIT has developed several standard test chips and the corresponding PCBs. Preferentially, two nested daisy chains are used, enabling short circuit detection between adjacent contacts that may result from process issues or whisker growth in accelerated aging tests. Furthermore, each daisy chain contains two positions for Kelvin probe measurements of the contact resistance, one at a corner and a second one in the center of one side. A typical design can be seen in figure 1.

ISIT test-chip boards are specially designed for material screening and process setup. 24 chip positions are arranged in three labeled segments with 8 numbered landing patterns each (figure 2). The boards can be used either for flip-chip mounting on top or wire bonding on the bottom side. Both sides of the board contain all the required fiducial marks for automated processing. All chip positions are surrounded by measurement pads for manual probing of the daisy chain connectivity. Depending on the pad function, different geometries are used: Pads corresponding to one daisy chain are rounded

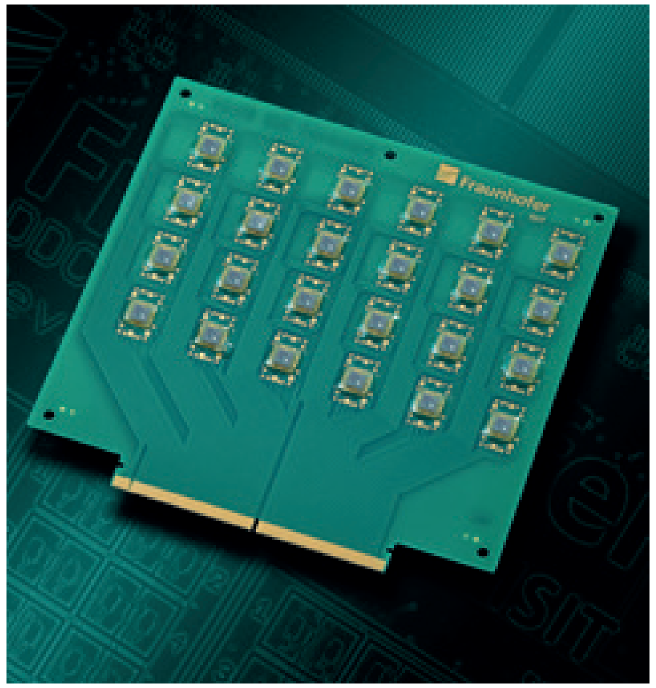


Figure 2: FC475 DDC test-chip evaluation board

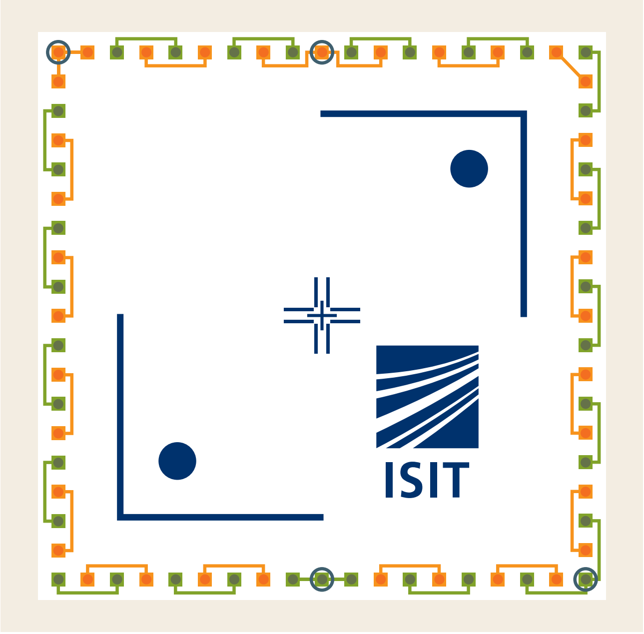


Figure 1: The FC475 DDC test chip with two nested daisy chains (red, green); Kelvin probe contacts are marked by circles

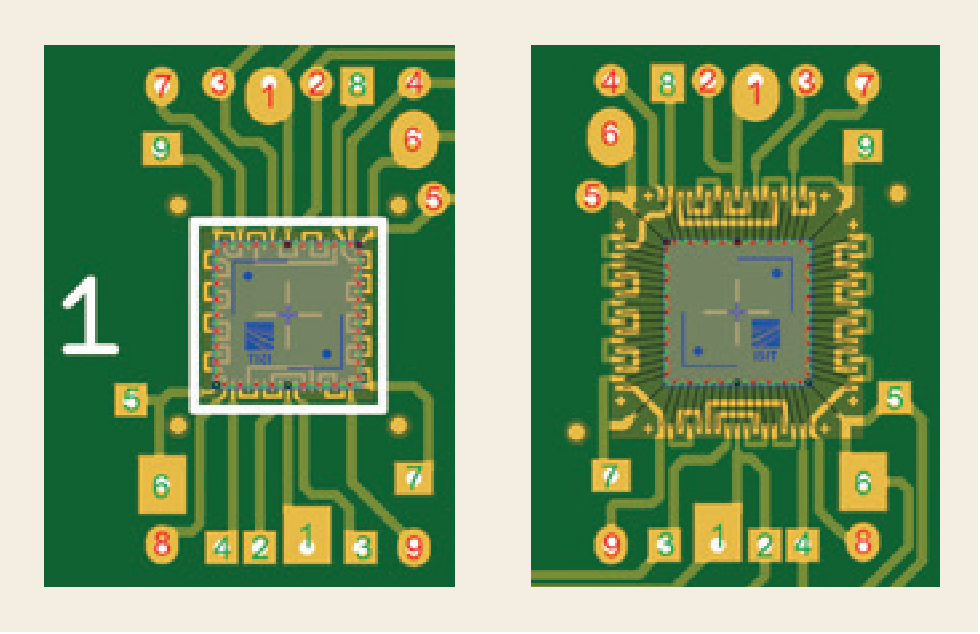


Figure 3: Detailed view of FC475 DDC flip chip and wire bond landing positions

whereas the other pads are rectangular. Large pads can be used to measure the complete daisy chain, small pads are used to measure only one side of the chip. To simplify manual probing, each pad features a PCB via in its center that provides secure grip for manual probe tips (figure 3).

Manual probing is a good choice for an initial process development and failure analysis. Material screening and accelerated aging tests however require a much faster automated test procedure with high accuracy. For this purpose, Fraunhofer ISIT has developed an electronic measurement setup. Used as a standalone system, the electronics board provides visual information about open connections and shorts (figure 5). Furthermore, single Kelvin probe connections can be selected to be measured by an external high precision ohm meter.

Combined with a 32 channel measurement system based on National Instruments CompactRIO® platform, a precise automated reliability assessment can be performed. The graphic user interface enables easy interpretation of the acquired data. The software executes an automated test of all daisy chain connections, analyzing the resistance as well as the isolation between the two nested chains. Depending on a user defined threshold, chips are marked as good, partly good, or shorted (figure 4). Furthermore, the single contact Kelvin probes are used to measure the contact resistance of two center and two corner connections for each chip.

Author: Dr. Dirk Kähler

Figure 4: Based on user defined thresholds the overview page of the measurement software indicates good and bad chips as well as short circuits graphically. Detailed measurement results can be obtained from the "Group A/B/C - Details" pages not shown in the image.

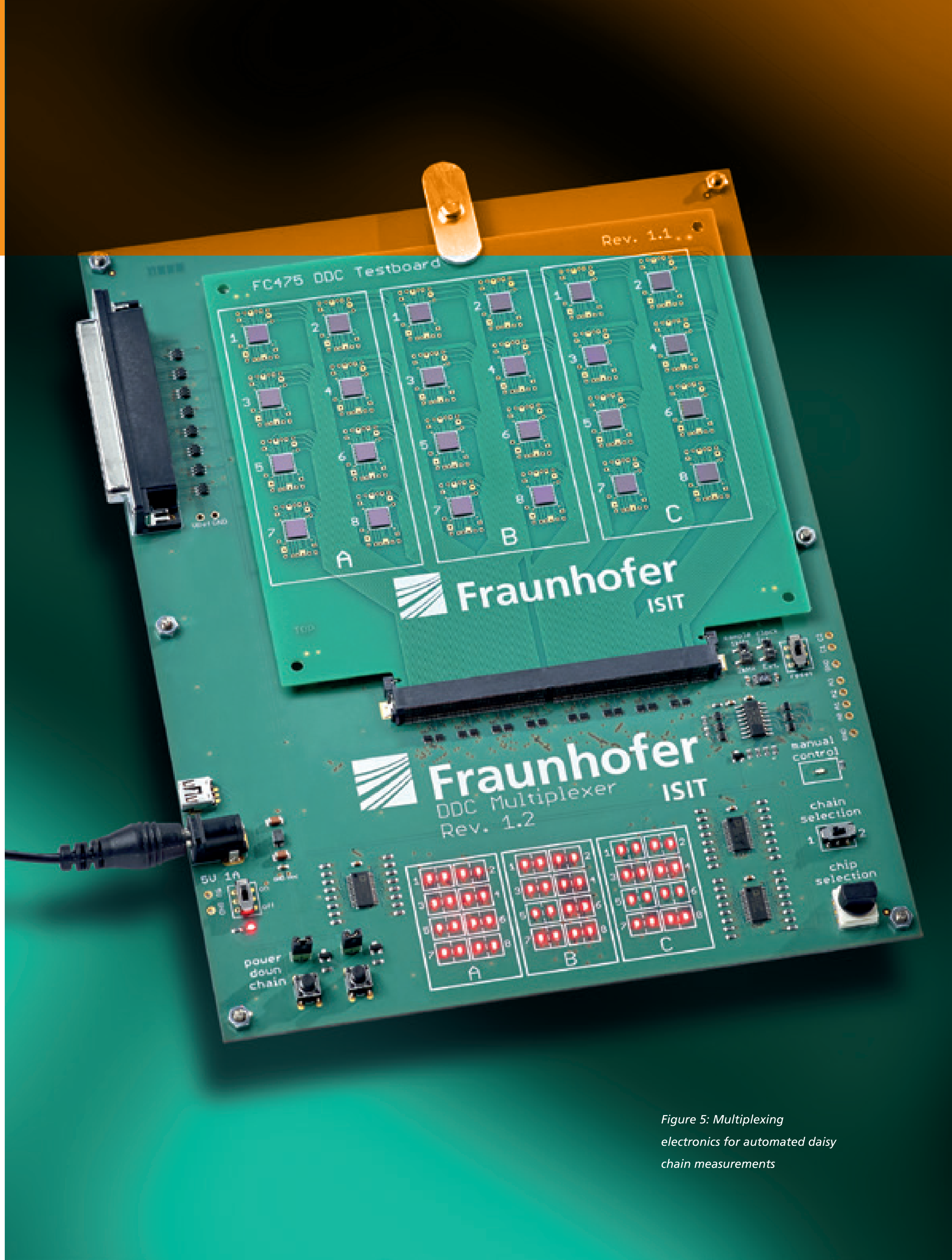
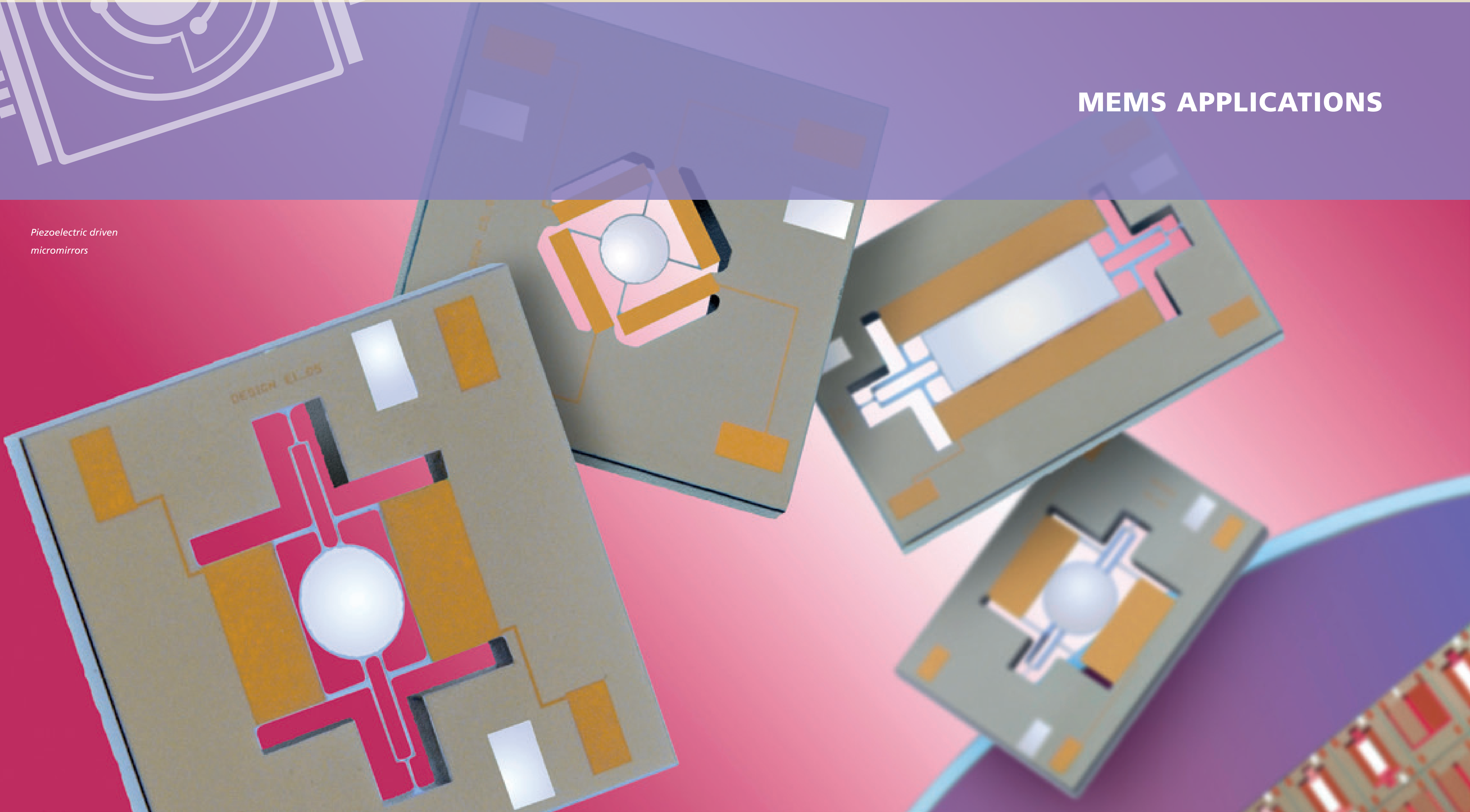


Figure 5: Multiplexing electronics for automated daisy chain measurements

MEMS APPLICATIONS



Piezoelectric driven micromirrors

PIEZOELECTRIC HARVESTER WITH MAGNETIC COUPLING

Magnetic scales are state of the art in industrial position sensing. Magnetic position sensors are robust against temperature changes, moisture, vibration and dust, while optical sensing provides higher resolution, but is more susceptible to harsh environments. AQUILA, a project funded by the German Federal Ministry of Education and Research (BMBF), targets to realize a magnetic positioning system with a spatial resolution below 100 nm. To achieve this goal, the project faces two main challenges: On one hand, smaller magnetic scales and more sensitive magnetoresistive sensors are required. On the other hand, the gap between sensor and scale has to be minimized.

But besides pushing the limits for measurement resolution, the objective in many industrial applications is also to allow a long term operation independent from external energy. Therefore, ISIT developed an integrated energy harvester for AQUILA's magnetic positioning system demonstrator.
The harvester converts available rotational energy into electrical energy. The concept is based on a cantilever with monolithically integrated magnets at the tip.
A mechanical excitation of the cantilever occurs while the harvester moves along magnetic poles. This causes the cantilever to deflect, which in turn generates charges in a piezoelectric layer deposited on the bending area of the cantilever.

AQUILA has started on January, 1st 2015 with a project volume of 3.75 million Euro. The consortium is led by Sensitec and consists of three companies and four research institutions, including Fraunhofer ISIT and Christian-Albrechts-University in Kiel (CAU) as cooperating partners for the development of the harvester technology.

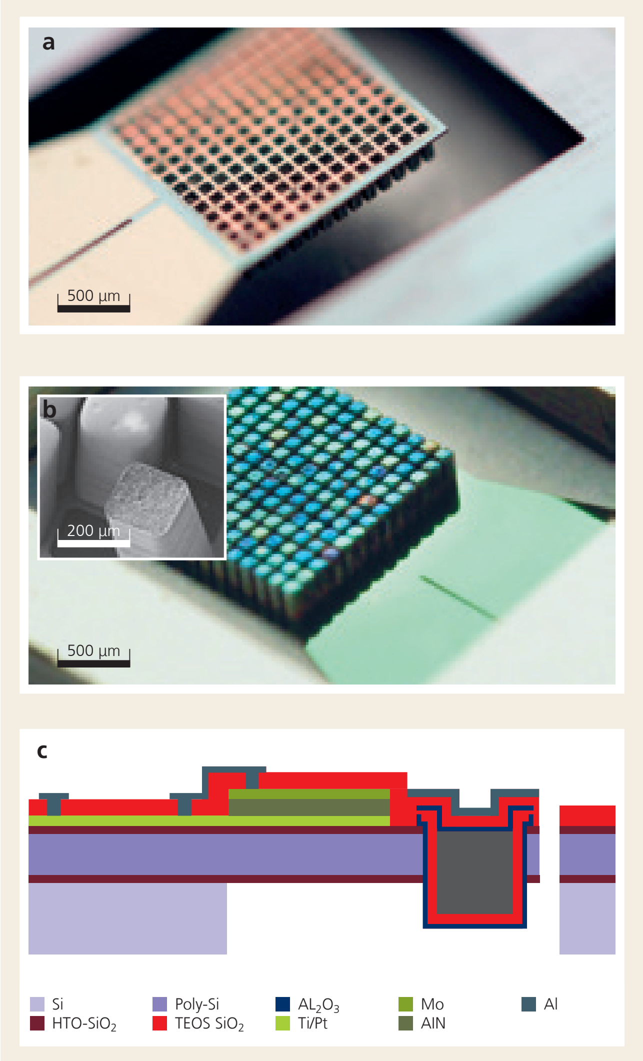


Figure 1: Magnetic energy harvester device from the front (a) and from the rear side (b). The inset depicts a SEM-image of a micro magnet. The whole structure consists of 13x 13 micro magnets. (c) Cross section drawing of the device.

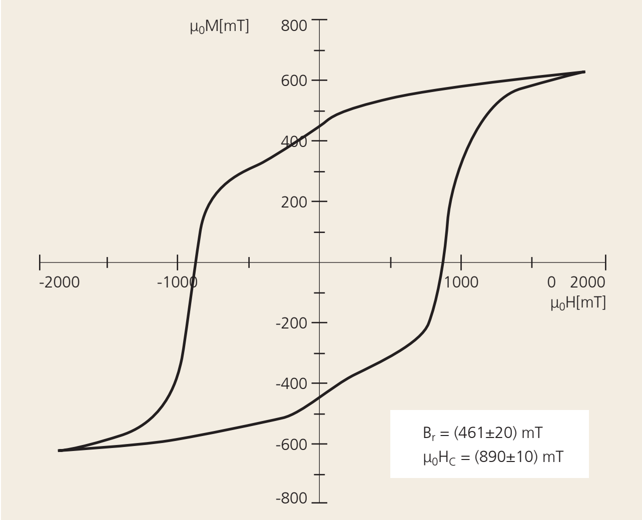


Figure 2: Typical intrinsic demagnetizing curve of the NdFeB micro magnets (particle size 4.5…6.5 µm)

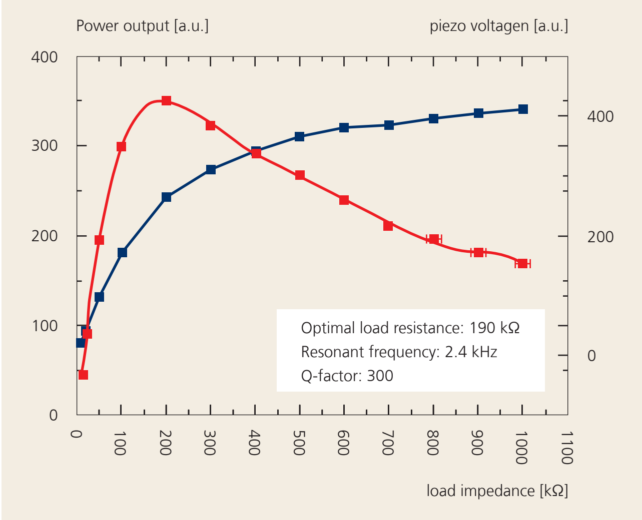


Figure 3: Measurement of power output (left scale) and piezo voltage (right scale) of the magnetic energy harvester versus load resistance. The measurement is performed on a mechanical shaker. The optimal load resistor is 190 kΩ.

MEMS technology
The monolithically integrated harvester technology consists of three basic elements:

- the cantilever with a piezoelectric layer of AlScN delivers electrical energy from deflection,
- micro magnets with a high remanence B_r and a coercivity μ_0H_C on the cantilever tip, and
- a waferlevel vacuum package that reduces damping losses and keeps dust and humidity away.

The harvester is fabricated by ISIT on 8" wafer technology and uses of a 50 µm thick polysilicon layer as substrate, as figure 1 indicates. A 2 µm thick piezoelectric AlScN layer is deposited on top by co-sputtering at CAU. Principally, the micro magnet is formed by etching cavities into the 8" Silicon wafer using deep reactive ion etching (DRIE) and filling NdFeB powder with a typical particle size of 4.5 – 6.5 µm into the cavities by squeegeeing. The powder becomes a solid agglomerate through atomic layer deposition (ALD), a process that allows depositing ultra-thin conformal coatings in the tiny inter-particle gaps and spaces. Residual NdFeB particles on the wafer surface are released by etching a previously deposited sacrificial copper layer. A nitride layer protects the surface against scratches. The resonator structure is then defined by front side DRIE and, finally, the magnetic energy harvester is released by backside DRIE.

Experimental results

The performance of the micro magnets is evaluated by characterizing their magnetic properties, which are the remanence B_r = 660 mT and coercivity $\mu_0 H_c$ = 890 mT, as figure 2 shows.

By using a shaker experiment, the optimal load resistance is determined. In figure 3, the measurement of power output (left scale) and piezo-voltage (right scale) of the magnetic energy harvester is plotted versus load impedance. The optimal load resistor is 190 kΩ in this case.

By using a spinning wheel with 32 cylindrical magnets of 2 mm diameter and 5 mm length, the performance of the harvester is evaluated (see figure 4 inset). Close to breakage of the resonator at a gradient field of about 10 T/m and a correlated force of about 1 mN, the device generates an output power of 110 µW at its resonance of 2.4 kHz (figure 4).

Using the same shaker experiment as before, it is possible to harvest electrical energy in an electrolyte capacitor by using a commercial harvester IC (figure 5).

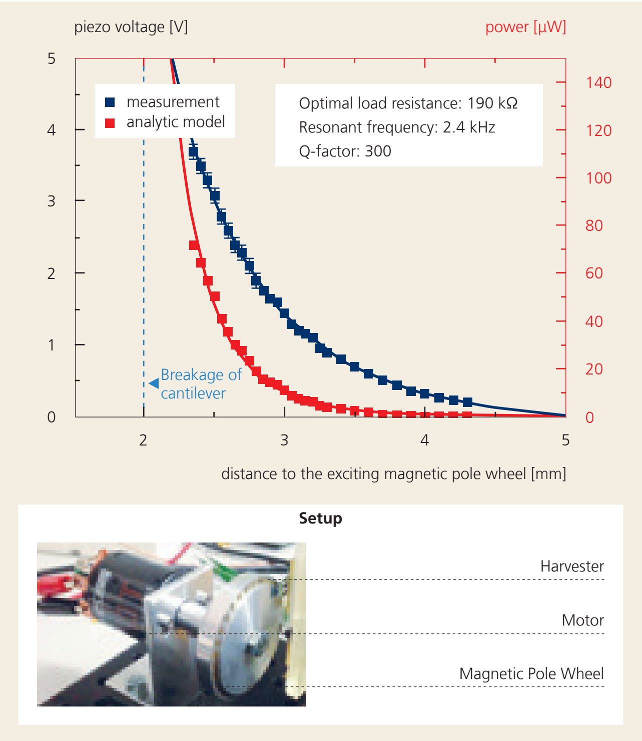


Figure 4: Result of the magnetic pole wheel with the distance of the harvester on the x-axis and the output voltage on the y-axis

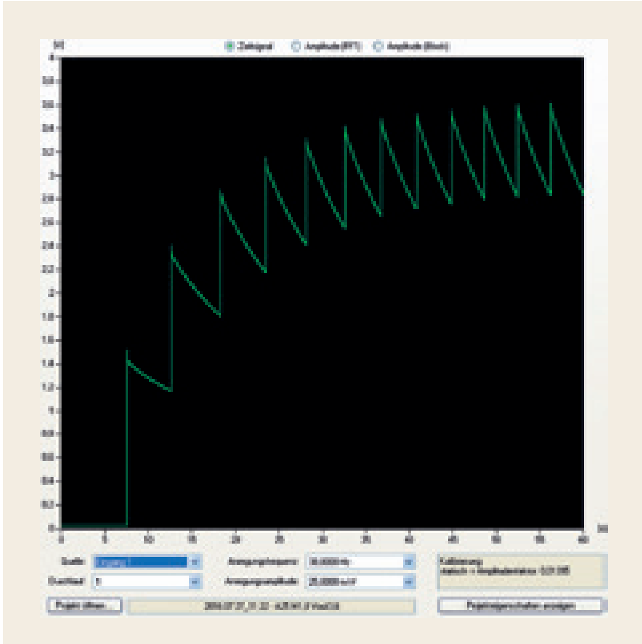


Figure 5: Voltage gradient of the capacitor. Every 5 seconds, an amount of about 0.1 mWs is stored in a 47 µF electrolyte capacitor

Conclusion

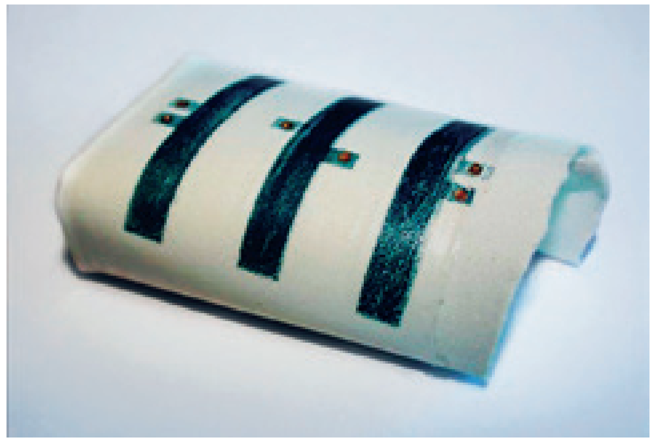
The first piezoelectric MEMS energy harvester with monolithically integrated high-energy-density micro magnets is presented. At resonance, a power output of up to 110 µW is reported which is orders of magnitude higher than state-of-the-art magnetic MEMS harvesters. Due to the high energy density and large volume of the integrated micro magnets, the harvester exhibits a high area-normalized power output of about 40 µW/mm².

Author: Jörg Eichholz

TRACKING BODY MOTION WITH PRINTED PIEZOELECTRIC SENSORS

Wearable electronics, or briefly "Wearables", have become a massive trend in the present decade. Integrated into clothing textiles, shoes or bracelets, they measure and track fitness parameters, body motion and ambient conditions. The user can record and analyze his or her individual activity, correlate it with fitness profiles or observe long-term trends in his or her individual training schedule. Market observers expect a significant impact over the next few years in the medical and sports sector, but also automotive and industrial companies show interest.

Tracking human body motion is one of the earliest, but still evolving use cases for wearables. Following the inertial sensors revolution, the integration of printed sensors in garments continues to raise market potential in the medical and sports sector. One motivation is to identify wrong motion patterns, e.g. to prevent repetitive strain injury of warehouse workers, but also to refine sports practicing techniques or to monitor patients in their physical rehabilitation.



In human motion tracking, many challenges still have to be addressed. A body pose involves many partially constrained degrees of freedom that have to be monitored in parallel. Sensors and electronic modules have to be mechanically robust, flexible and waterproof or even washable.
For a widespread implementation, all elements have to be affordable and easy to use.

In the BMBF funded collaboration project "MoniShirt" (Förderkennzeichen 16SV7353), Fraunhofer ISIT and ISC advanced the development of a stretchable sensor system: Piezoelectric sensors were screen-printed and encapsulated on textiles, e.g. for measuring wrist bending movements (figure 1) [1]. The textile-integrated sensors withstand 1 hour machine washing at 30°C and more than 100 bending cycles were executed without damage.

Fraunhofer ISIT characterized the sensors and developed signal assessing electronics as well as an intuitive visualization software that allows users to observe their movements or performance (figure 2).

Signal quality and mechanical stability of the sensors printed on planarized fabrics were evaluated with a bending and torsion setup on a mechanical test bench. The sample was

Figure 1: Screen printed and encapsulated piezo sensors on planarized fabrics with silver electrodes designed for wrist bending movement detection (© Fraunhofer ISC)

Figure 2: Signal visualization of a bent torsion sensor on PET for elbow measurement

clamped at two edges between the machine basis and a moveable clamp holder, allowing to exert a reproducible bending action while simultaneously logging the sensor voltages and traverse position (figure 3). For torsion testing, an additional setup to translate perpendicular traverse movement into rotation was used. The torsion angles were varied in cycles between 0° (flat sample) and 70°. The torsion tests were carried out at three different traverse movement velocities (5 mm/s, 10 mm/s, 15 mm/s). figure 4 shows a measurement curve for 15 mm/s.

The sensor uses the piezoelectric effect, i.e. a voltage is generated that actually correlates with the dynamic change in bending rather than indicating a position. For calculating the movement velocity and distance (angle), the signal has to be integrated once or twice, respectively, while keeping the starting value as the reference (integration constant). Hence, significant voltage peaks are obtained when the velocity changes at the lower and upper bending and torsion limits (figures 3 and 4).

Although a measurable signal was principally obtained, a high noise level was observed and some expected signal peaks were missing (see the "?" in figure 3). Compared with torsion measurements (figure 4), the bending action only generates a small signal output. The absence of some peaks may be due to the fact that the bending radius is not defined by the apparatus but arbitrarily follows the sheet deformation. Hence, bending mostly occurred on a small sensor area while most of the sensor remained more or less straight. Since the signal amplitude depends on the bent area, this situation leads to a smaller signal compared to the torsion setup that involves the whole sensor area in a twisting action. Consequently, the torsion analysis shows a higher signal to noise ratio as well.

From these torsion experiments, a first evaluation could be driven to determine how the sensor voltage depends on the torsion angle. In figure 5, a first calculated curve with each point being comprised of five torsion measurement is shown. There is a considerable voltage spread due to noise effects. However, a rough linear behavior can be assumed.

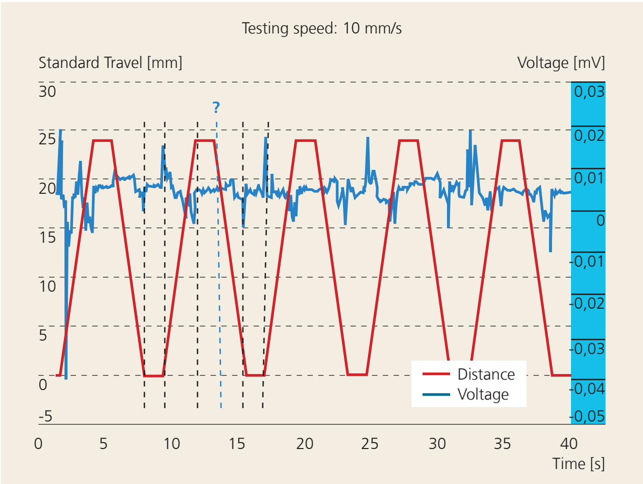


Figure 3: Voltage-time characteristics (bending test, planarized cleanroom cloth substrate). Some signals are obviously below the signal noise level (indicated by a "?")

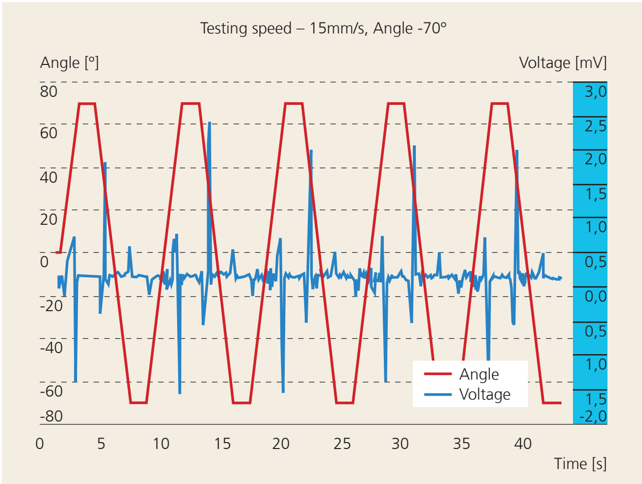


Figure 4: Voltage over time graph (torsion setup, planarized cleanroom cloth substrate)

The next development steps will aim for increasing the sensitivity via enhanced fabrication parameters as well as integration and optimization of low power wireless electronics on wearable textiles. This will move us a step closer to a stretchable sensor system that is easy to integrate and use for sports, work environments or everyday garments. Moreover, a physical sensor modification has to be done in order to mitigate pyro sensitive effects.

Author: Dr. Thomas Knieling

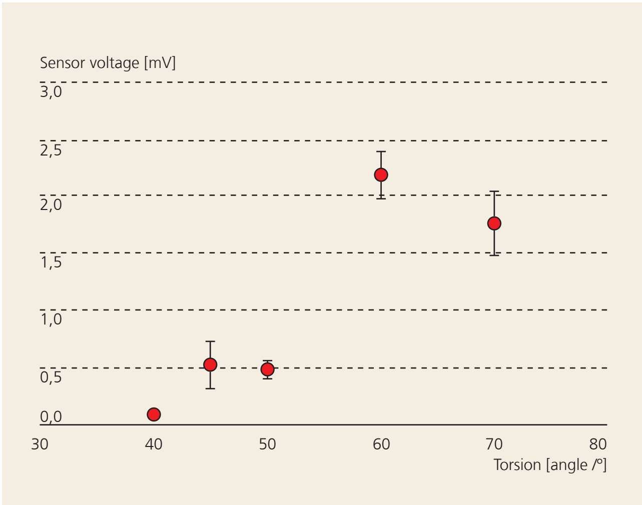


Figure 5: Correlation between sensor voltage and torsion angle. Each point results from five measurements. Values for torsion angles < 40° are buried in noise. Noise may be caused mainly by low sensor sensitivity, pyroelectric effect and friction charging.

References:

R. K. Raja Mahendra Varman, T. Knieling, T. Grunemann, G. Domann: MoniShirt – Large area printed piezoelectric sensors for body motion tracking (paper and presentation), Smart Systems Integration Conference 2017, Cork, Ireland.

Flexible biosensors

VISUALIZING HEALTH PARAMETERS ON AN OLED DISPLAY FOR WEARABLES

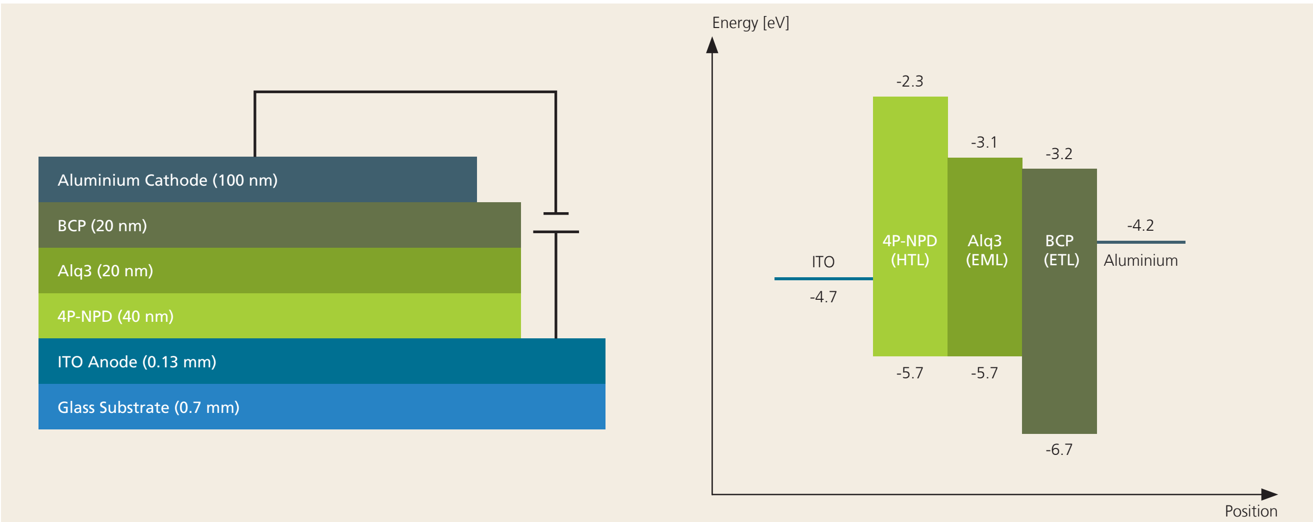
Human health monitoring generally implies measuring heart rate and body temperature. In a collaboration project between Syddansk Universitet Sonderborg, Denmark, Hochschule Bremen and ISIT, a sensor watch with an embedded and optimized OLED display was developed [1]. The OLED display was fabricated and optimized in Denmark. Assembly, driver and signal assessment electronics as well as characterization and test were done at ISIT.

The advantage of OLED technology compared to conventional solid state LEDs is that displays can be built by defining area elements of arbitrary shapes and curves. Each OLED element comprises a standard bottom emitter layer stack as shown in figure 1. Typically, well-known evaporation methods are used for the deposition.

The layer thicknesses of BCP, Alq3 and 4P-NPD were varied in order to improve the power efficiency. Such variations affect the electric field gradient and thus influence the turn-on voltage, the electron-hole blocking properties and the resulting quantum efficiency. This will finally modify the location of the recombination region in relation to the reflective cathode.

As an example, the effect of changing the 4P-NPD layer thickness is shown in figure 2. An increase raises the optical power output, but requires a higher operating voltage.

Figure 1: Layer stack (left) and energy band diagram (right) for the applied OLED layer stack. BCP: Bathocuproine, Alq3: Tris(8-hydroxyquinolinato)aluminium, 4P-NPD: N,N´-di-1-naphthalenyl-N,N´-diphenyl-[1,1´:4´,1´´:4´´,1´´´-quaterphenyl]-4,4´´´-diamine, ITO: Indium Tin Oxide, HTL: Hole transport layer, EML: Emission layer, ETL: Electron transport layer



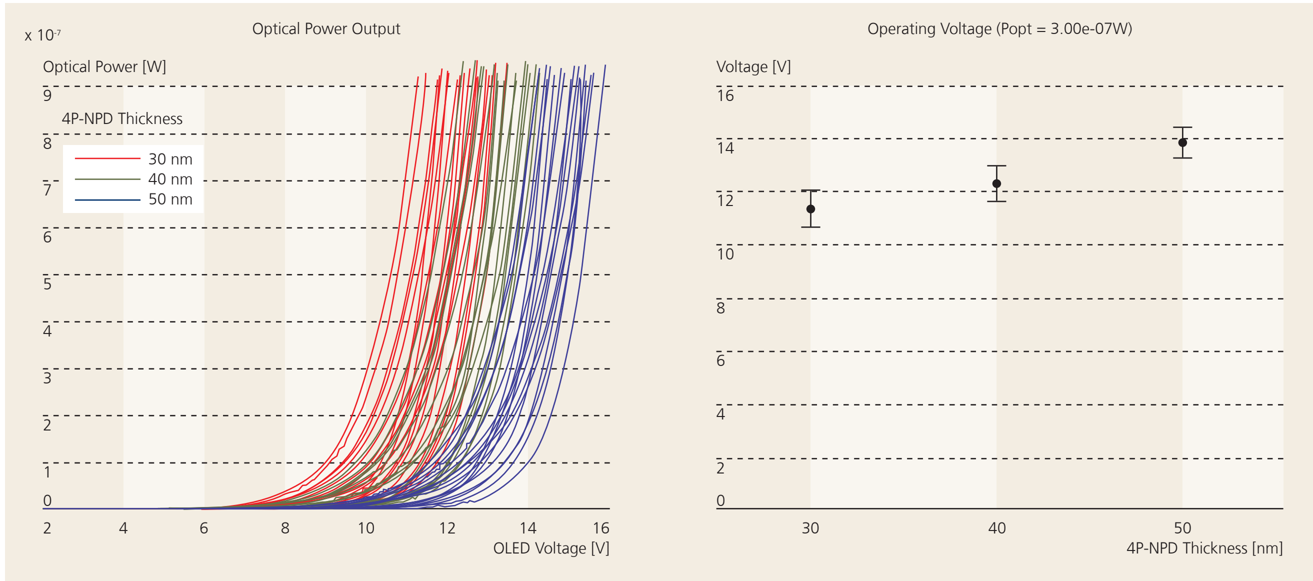


Figure 2: (left) Optical power output depending on OLED voltage. (right) Voltage as a function of the layer thickness

Organic Layer	Optimal Thickness (nm)	Explanation
BCP (Electron Transport Layer)	10 20 30 Initially 20 nm	Increased hole blocking capabillity and/or reduced outcoupling losses
Alq3 (Emission Layer)	10 20 30 Initially 20 nm	30 nm more current efficient due to reduced outcoupling losses, but less power efficient due to increase in operating voltage
4P-NPD (Hole Transport Layer)	30 40 50 Initially 40 nm	Sufficient electron blocking capability at 30nm; thicker layer results in higher operating voltage

Table 1: Overall effect of layer thickness variations in the standard OLED stack. According to these results, the thicknesses were changed into the red marked values.

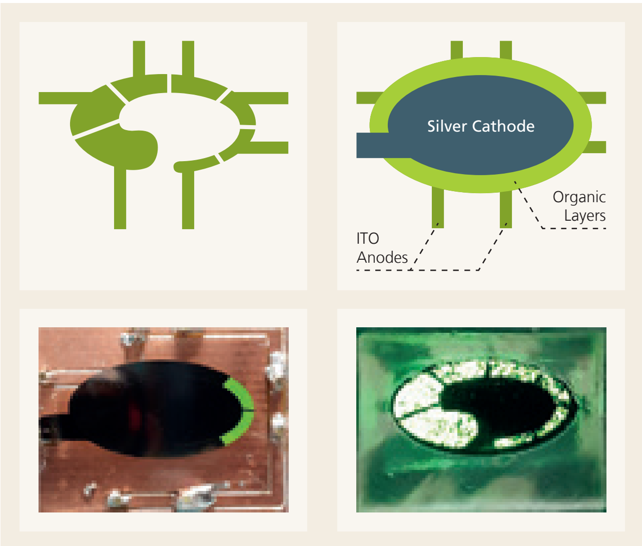


Figure 3: OLED display design for health parameter indication and visualization. Upper left: Structured ITO anode. Upper right: Display structure. Lower left: Two segments addressed directly after fabrication. Lower right: All segments addressed, degradation (mainly the ITO anode) after three months.

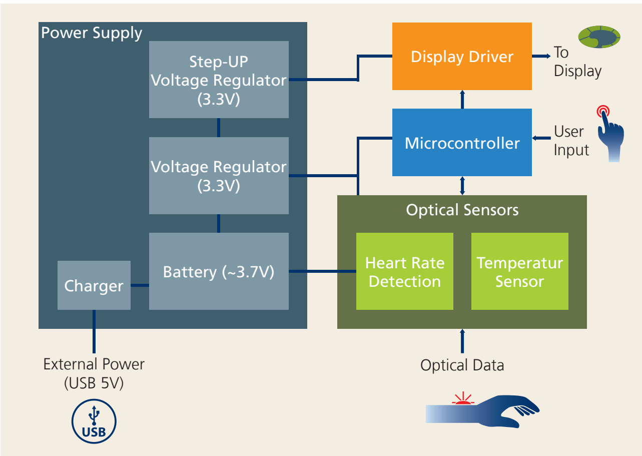


Figure 4: System architecture of the OLED sensor wristband

The overall effect of layer thickness variations is shown in table 1. Hence it was shown that a simple layer thickness variation by some nm in the standard stack improved considerably and reproducibly the OLED performance.

The OLED display for indicating heart rate and skin temperature was designed as shown in figure 3. Its curved overall shape is composed of seven different segments. The display was formed on a rigid glass carrier and encapsulated in a Nitrogen atmosphere using a glass cap.

A considerable degradation after some months was noticed (Figure 7, lower right) that also affected the previously calculated driving parameters: The operating voltage increased from 12.32 V to 17 V and the current increased from 7.5 mA to 16…60 mA, respectively. It will be of crucial interest to reduce degradation effects in future.

For sensor and system assembly, it was decided to use commercially available parts. The two parameters heart rate (HR) and skin temperature were measured optically by infrared sensors. The skin temperature is correlated with the far-infrared radiation emitted from skin, hence a thermopile sensor was used. The HR is measured by so called photoplethysmography (PPG), using the near-infrared LED light reflection from pumped blood below the skin.

The electronic circuit is implemented in the wristband of the watch. It serves as the carrier for the OLED display and is thus partially flexible. The system is assembled by soldering; its architecture is schematically shown in figure 4.
Figure 5 shows the whole wristband. The design was made by one person in a half year master thesis and performs as expected. Some exemplary HR measurements are shown in figure 6, while figure 7 illustrates how a typical temperature measurement is seen on the OLED display.

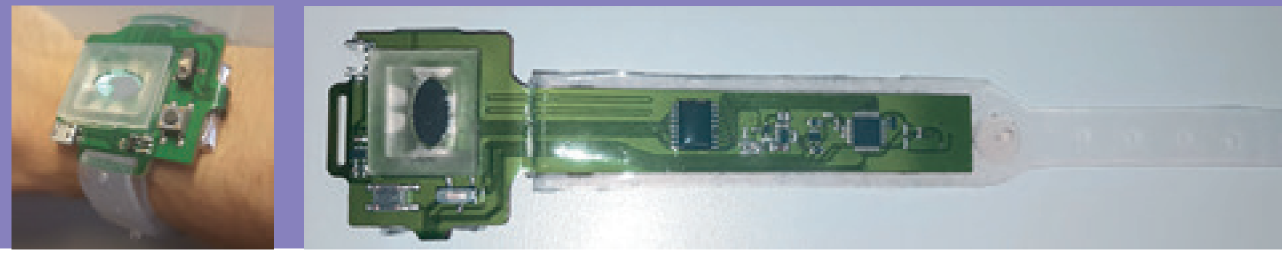


Figure 5: OLED wristband with integrated optical sensors for heart rate and temperature measurement

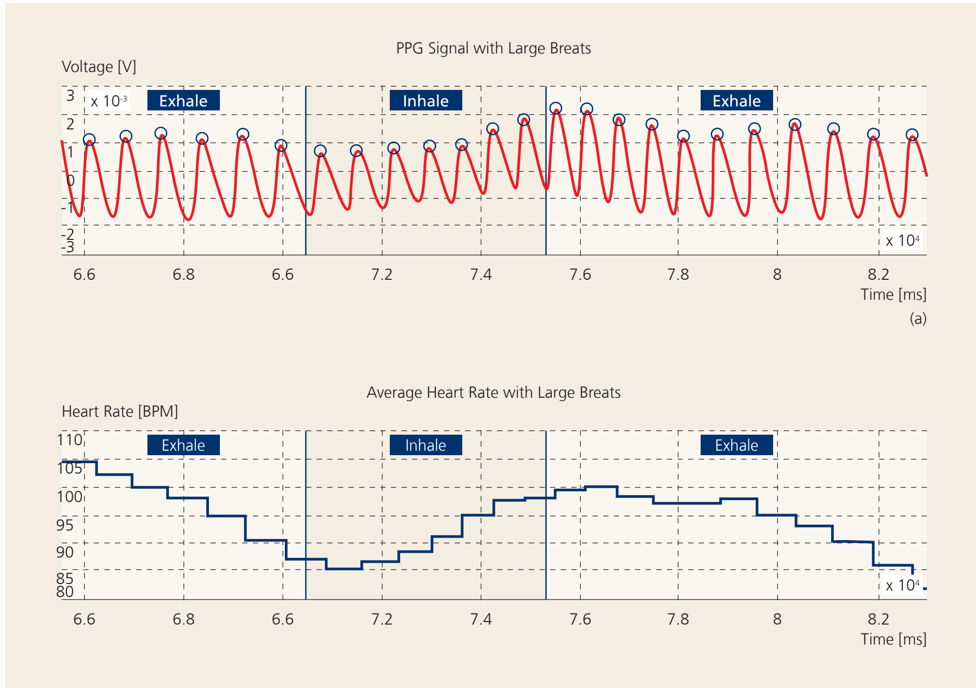


Figure 6: HR measurements through optical sensing. Upper graph: Pulse frequency. Lower graph: Heart rate in correlation with the breathing activity.

Figure 7: The infrared skin temperature measurement is indicated by the OLED segment display

Author: Dr. Thomas Knieling

MEMS FABRICATION

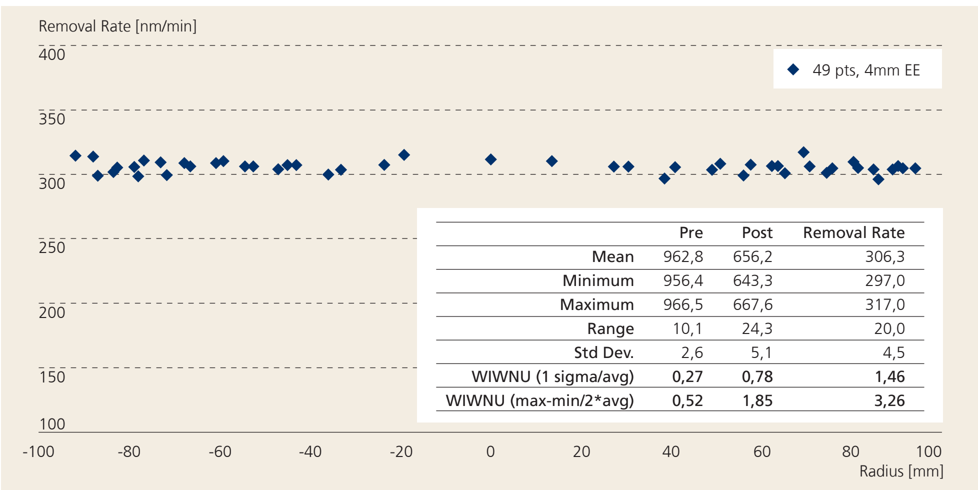
Wafer dicing and grinding area in the MEMS cleanroom

PLANARITY AT THE NANOMETER SCALE: CHEMICAL-MECHANICAL POLISHING FOR MEMS

About three decades ago, chemical-mechanical polishing (CMP) became an enabler for CMOS processes since it allowed stacking more and more interconnect layers on top of each other. But also in the MEMS domain, CMP has evolved to an important key technology since the requirements in structure sizes and layer stacks increased extremely. Since many years, Fraunhofer ISIT gained expertise through a long-term research cooperation with former Peter Wolters GmbH, based on the PM200 CMP tool, which is still in use and provides a high flexibility with respect to wafer size and wafer thickness. However, for modern semiconductor requirements, e.g. three millimeters edge exclusion, the tool is not suitable any more.

Therefore, ISIT installed a new state-of-the-art CMP tool from EBARA for 200mm wafer processing, the FREX200. This equipment marks a new era for modern CMP processing at Fraunhofer ISIT. The FREX200 is a „dry-in, dry-out“ polisher for industrial processes like STI (shallow trench isolation) with a multi-zone membrane pressure chuck (AI2 head) that provides three millimeter edge exclusion in addition to an optimal removal behavior that guarantees high uniformity of layer stacks.

The FREX200 has two parallel polishing routes with four load-stations, two 24“ turntables for main polishing and two buffing tables for surface finishing. On both sides, two cleaner stations with conventional pre-cleaning and final-cleaning unit (contact cleaning with PVA brushes) are available and, after final cleaning, the wafers are dried by spinning. Both cleaner stations allow megasonic cleaning and provide two chemical lines for different chemistries like ammonia or citric acid. The concept promises clean and particle-free surfaces for all kinds of MEMS applications, without any sticking abrasive residues from polishing slurries (abrasive particles).



	Pre	Post	Removal Rate
Mean	962,8	656,2	306,3
Minimum	956,4	643,3	297,0
Maximum	966,5	667,6	317,0
Range	10,1	24,3	20,0
Std Dev.	2,6	5,1	4,5
WIWNU (1 sigma/avg)	0,27	0,78	1,46
WIWNU (max-min/2*avg)	0,52	1,85	3,26

Figure 1: The CMP removal rate on oxide wafers indicates a good uniformity

Needs for CMP processes with improved non-uniformity and reliable surface smoothness

Through many different projects, ISIT developed CMP recipes for a broad range of MEMS technologies and many different types of materials are available. A large portfolio of analytic techniques is available in-house, e.g. optical reflectometry, 4-point-probing conductivity analysis, advanced surface investigations using AFM or white light interferometer, and planarity evaluation by profilometry.

First investigated processes have shown impressing results with respect to uniformity and surface smoothness after CMP. In this report, we shortly present results from an oxide and a poly-silicon process.

Oxide CMP process for preparing Borofloat glass wafers for subsequent bond processes

The oxide CMP process is routinely performed for anodic bonding of glass on Silicon. The uniformity of Borofloat glass wafers and the smoothness of the wafer surfaces are the most important criteria for anodic bond processes. Before CMP, the glass wafers are thinned by grinding, a harsh mechanical abrasion process that creates many defects on the wafer surface. CMP is the optimal solution for conditioning these surfaces according to the bond process requirements.

To study the impact of CMP on glass surfaces, the process performance was investigated on oxidized Silicon wafers since it is not possible to measure uniformity on transparent glass wafers with available equipment. Figure 1 shows that a good result was achieved, with an acceptable removal rate of 300 nm/min. The standard deviation of 1.46 % indicates a uniform surface after CMP.

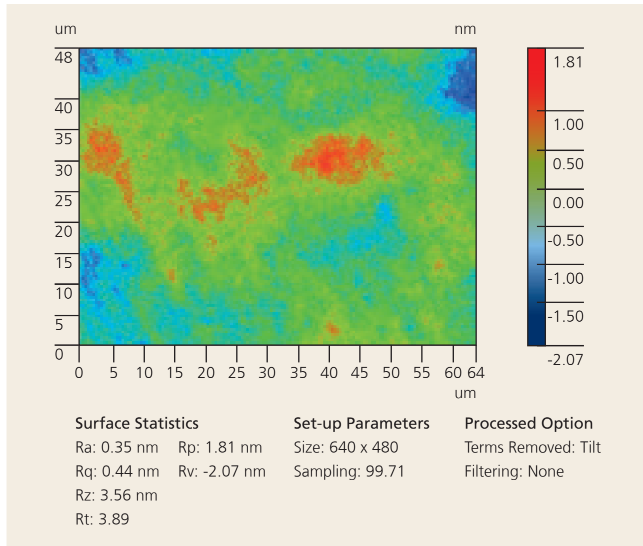
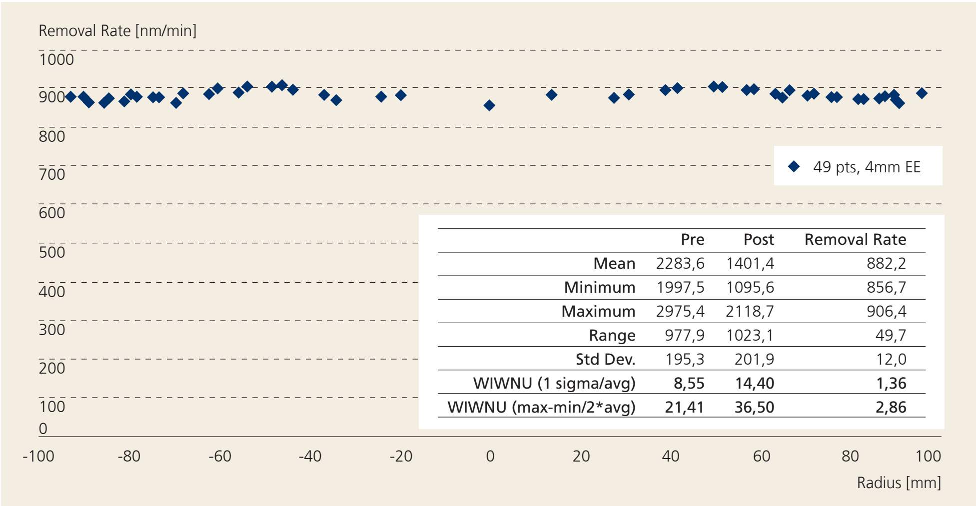


Figure 2: A smooth oxide surface is obtained by CMP

For surface finishing, a buffing step was developed on a buffing table, frequently called „banana“ table because of its shape. The buffing table is exclusively used for surface finishing with a soft pad to obtain the highest possible surface smoothness. Figure 2 shows the Ra-value (standard value for roughness) of 0.35 nm on Borofloat glass wafer after the buffing step, which is sufficient for the subsequent bonding process.

Epitaxial polysilicon CMP for preparing optical surfaces

The polysilicon CMP process is needed for generating optical surfaces in scanning micromirror devices. The mirror plates are usually very rough after the epitaxial polysilicon deposition. Concerning CMP, the requirements are similar to Borofloat glass wafers: Excellent in-layer uniformity and high surface smoothness are needed for optical surfaces and can be achieved by the CMP process. However, the high roughness after the polysilicon epitaxy, usually in the micrometer-range,



	Pre	Post	Removal Rate
Mean	2283,6	1401,4	882,2
Minimum	1997,5	1095,6	856,7
Maximum	2975,4	2118,7	906,4
Range	977,9	1023,1	49,7
Std Dev.	195,3	201,9	12,0
WIWNU (1 sigma/avg)	8,55	14,40	1,36
WIWNU (max-min/2*avg)	21,41	36,50	2,86

Figure 3: Removal rate and statistics on epitaxial polysilicon

requires an adequate removal rate, otherwise the process time is too long and the CMP step becomes too expensive. The achieved removal rate of ca. 900 nm/min is acceptable and the standard deviation (non-uniformity) is 1.36 %. The measurement was performed by reflectometer and results are shown in figure 3.

After main polish, the buffing step is necessary to obtain a high surface smoothness for optical applications. In addition, silicon is hydrophobic by nature, while contact cleaning with PVA brushes necessitates a hydrophilic surface to avoid particle stiction on the wafer surface. Particles originate from abrasives and other slurry residues. The results with buffing step show a very smooth surface after CMP: With a Ra-value of 0.86 nm, the surface is perfectly prepared for mirror applications.

Author: Benjamin Streible

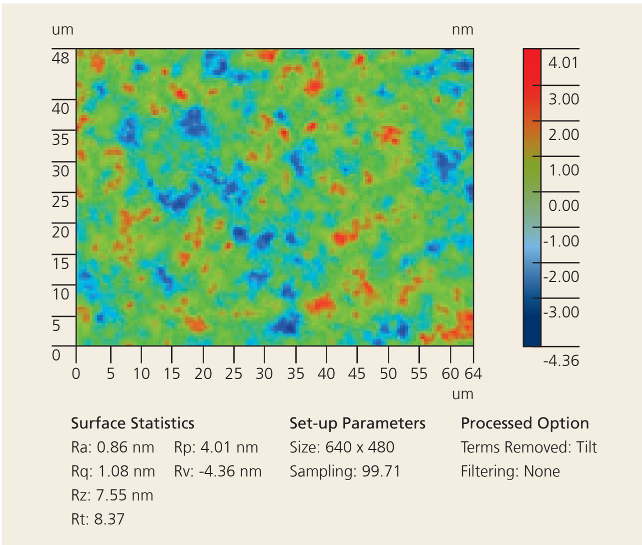


Figure 4: Surface inspection after polysilicon CMP

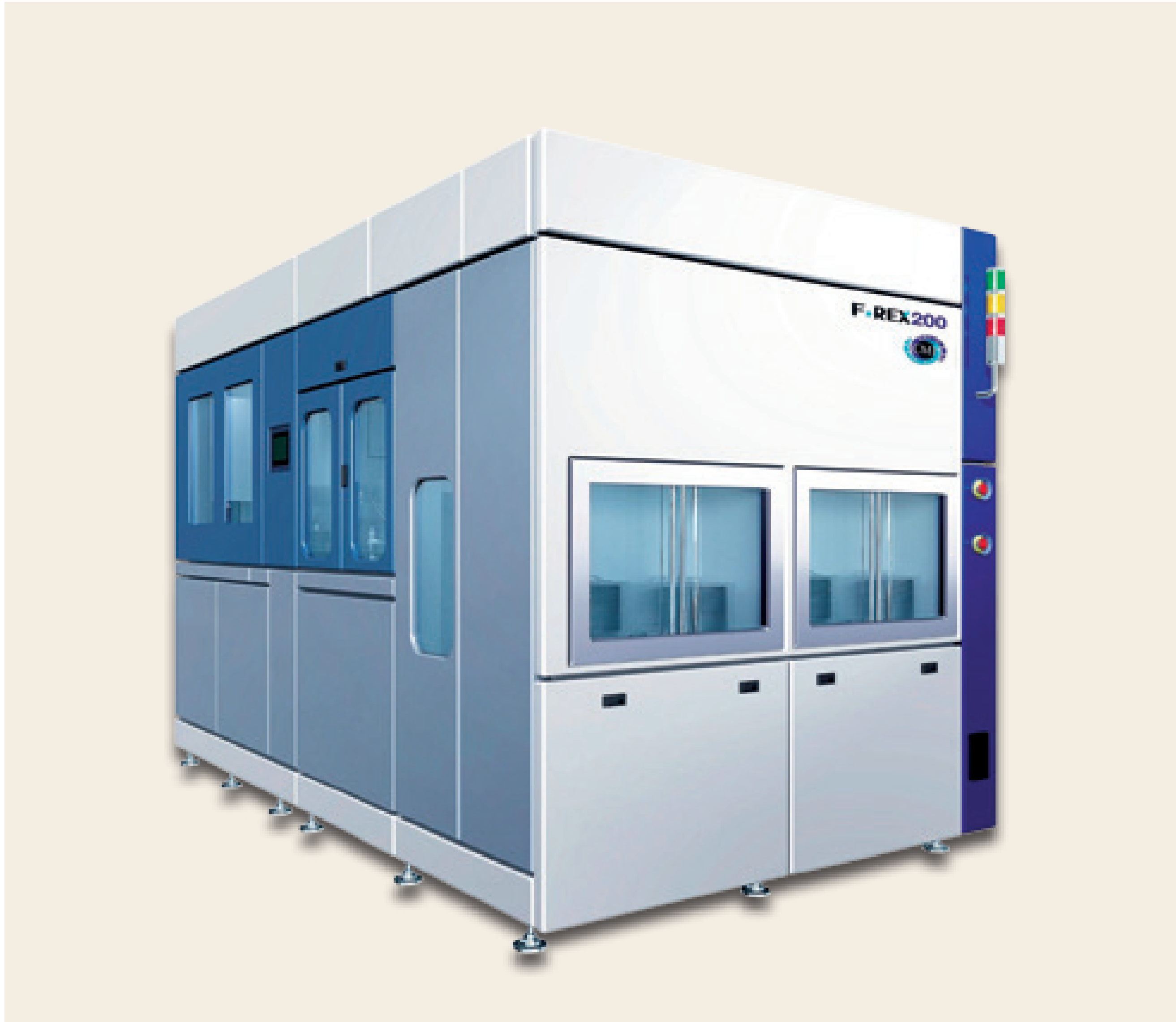
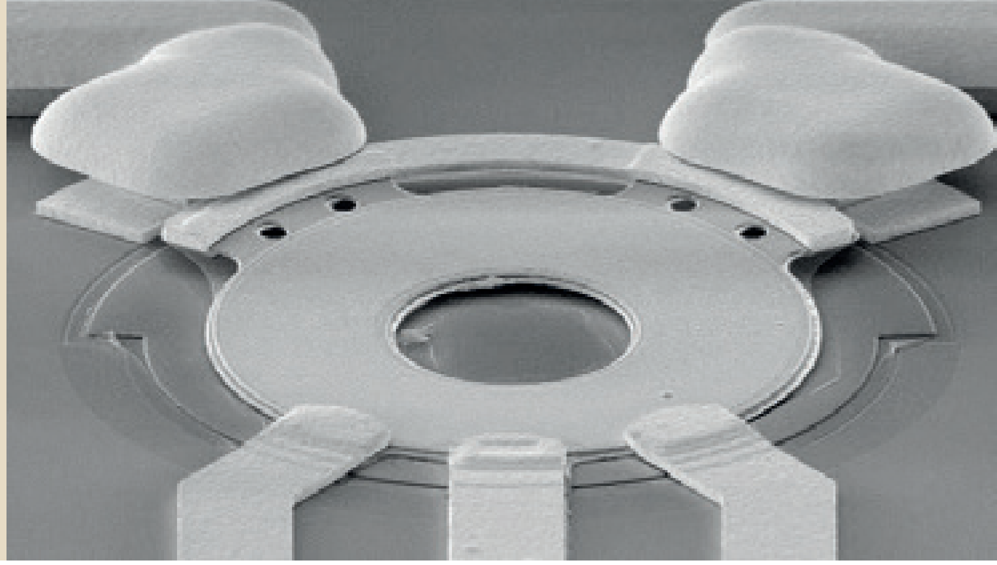


Figure 5: EBARA State-of-the-art CMP tool EBARA FREX200.

IMPORTANT NAMES, DATA, EVENTS

Presenting ISIT research topics on the open day of High Tech Itzehoe: Sascha Bohse, Dr. Dirk Kaden and Fabian Stoppel



Customers

ISIT cooperates with companies of different sectors and sizes.
In the following, some companies are presented as a reference:

3-D-Micromag GmbH, Chemnitz

Adam Opel AG, Rüsselsheim

Advaplan Inc., Espoo, Finland

Airbus-Systeme, Buxtehude

aixACCT Systems GmbH, Aachen

Akzo Nobel N.V., Göteborg, Sweden

Aluminium-Veredelung GmbH, Ennepetal

alpha-board GmbH, Berlin

Amicra Microtechnologies GmbH, Regensburg

Applied Materials Italia SrL, Olmi di S. Biagio di Callalta

Asteelflash Hersfeld GmbH, Bad Hersfeld

Basler AG, Ahrensburg

BESB GmbH, Berlin

Besi APac Sdn. Bhd., Shah Alam, Malaysia

Besi Austria GmbH, Radfeld, Austria

BMZ GmbH, Karlstein am Main

Bosch Sensortec GmbH, Reutlingen

B. Braun Melsungen AG, Melsungen

H. Brockstedt GmbH, Kiel

Brose Fahrzeugteile GmbH & Co. KG, Hallstadt

Brückner Maschinenbau GmbH & Co. KG, Siegsdorf

CAMPTON Diagnostics UG, Itzehoe

CAPRES A/S, Kongens Lyngby, Denmark

Cassidian Communications GmbH, Ulm

CCI GmbH, Itzehoe

Christian Koenen GmbH, Ottobrunn-Riemerling

Condias GmbH, Itzehoe

congatec AG, Deggendorf

Continental Automotive GmbH, Karben

Conti Temic microelectronic GmbH, Nürnberg

Cytocentrics Bioscience GmbH, Rostock

Daimler AG, Stuttgart

Danfoss Drives A/S, Graasten, Denmark

Danfoss Silicon Power GmbH, Flensburg

Davengo GmbH, Berlin

DELO Industrie Klebstoffe GmbH & Co. KGaA, Windach / München

Dräger Safety AG & Co. KG, Lübeck

Dräger Systemtechnik, Lübeck

Endress + Hauser GmbH Co. KG, Maulburg

Engineering Center for Power Electronics GmbH, Nürnberg

Eppendorf Instrumente GmbH, Hamburg

ERSA GmbH, Wertheim

ESCD GmbH, Brunsbüttel

ESPROS Photonics AG, Switzerland

Evonik Litarion GmbH, Kamenz

Exceet Secure Solutions GmbH, Düsseldorf

FeCon GmbH, Flensburg

FHR Anlagenbau GmbH, Ottendorf-Okrilla

First Sensor Lewicki GmbH, Oberdischingen

FMP TECHNOLOGY GMBH, Erlangen

Freudenberg Gruppe, Weinheim

FTCAP GmbH, Husum

Garz & Fricke GmbH, Hamburg

Hako GmbH, Bad Oldesloe

Hanking Group, China

Hannusch Industrieelektronik e.K., Laichingen

Harman Becker Automotive Systems GmbH, Karlsbad

Hauzer Techno Coating BV, Venlo, Netherlands

Hella KG, Lippstadt

Heraeus Materials Technology GmbH Co. KG, Hanau

HUAWEI Technologies Düsseldorf GmbH, Düsseldorf

Ifm ecomatic GmbH, Kressbronn

Ifm ecomatic GmbH, Essen

IMS Nanofabrication AG, Wien, Austria

In-Core Systems SARL, Saint Priest, France

INGECAL, Vaux en Velin, France

ISRA Vision AG, Darmstadt

JAQUET Technology Group AG, Basel, Switzerland

Jenoptik ESW GmbH, Wedel

Johnson Matthey Battery Materials GmbH, Moosburg

Jonas & Redmann Group GmbH, Berlin

Jungheinrich AG, Norderstedt

Kendrion Kuhnke Automation GmbH, Malente

Kristronics GmbH, Harrislee-Flensburg

Kulicke & Soffa Germany GmbH, Nuremberg

Laser Display Technology GmbH, Jena

Liebherr Elektronik GmbH, Lindau

Melexis Ieper N.V., Belgium

Miele & Cie KG, Lippstadt

ml&s GmbH, Greifswald

m-u-t GmbH, Wedel

M+W Group, Stuttgart

Novelis Deutschland GmbH, Göttingen

Nexperia Germany GmbH, Hamburg

OSRAM GmbH, München

Otto Bock Health Care GmbH, Duderstadt

PAC Tech, Packaging Technologies GmbH, Nauen

Peter Wolters GmbH, Rendsburg

Philips Medical Systems DMC GmbH, Hamburg

Plath EFT GmbH, Norderstedt

PRETTL Elektronik Lübeck GmbH, Lübeck

RAWE Electronic GmbH, Weiler-Simmerberg

Reese + Thies Industrieelektronik GmbH, Itzehoe

Renault SA, Boulogne, Billancourt, France

Rheinmetall Landsysteme GmbH, Kiel

Robert Bosch GmbH, Renningen

Robert Bosch GmbH, Reutlingen

Robert Bosch GmbH, Salzgitter

ROHDE & SCHWARZ GmbH & Co. KG, München

SAFT SA, Bagnolet, France

Saint-Gobain Centre de Recherches et d'Etudes Européen, Courbevoie, France

Science&Motion Sports GmbH, Rüsselsheim

Senvion GmbH, Osterrönfeld

SGL Carbon GmbH, Meitingen

Sicoya GmbH, Berlin

Siebtronic GmbH, Salzburg, Austria

SMA Regelsysteme GmbH, Niestetal

Solvionic Site SNPE, Toulouse, France

STABILO International GmbH, Heroldsberg

Still GmbH, Hamburg

Technolas Perfect Vision GmbH, München

Technosert Electronic GmbH, Wartberg ob der Aist

TESAT SPACECOM GmbH, Backnang

THM Faserverbund-Technologie GmbH, Alt Duvenstedt

Thyssen Krupp Marine Systems GmbH, Kiel

Torgeedo GmbH, Gilching

Trainalytics GmbH, Lippstadt

Trinamic Motion Control GmbH & Co. KG, Hamburg

Umicore NV, Olen, Belgium

University of Cambridge Department of Engineering, Cambridge, England

USound GmbH, Graz, Austria

Vakuum- und Präzisions-fertigung Dresden GmbH, Ottendorf-Okrilla

Venneos GmbH, Stuttgart

Vishay BCcomponents BEYSCHLAG GmbH, Heide

Vishay Siliconix Itzehoe GmbH, Itzehoe

Vishay Siliconix, Santa Clara, USA

Volkswagen AG, Wolfsburg

Von Ardenne Anlagentechnik GmbH, Dresden

WABCO GmbH, Hannover

Aug. Winkhaus GmbH & Co. KG, Telgte

Witt IndustrieElektronik GmbH, Berlin

Würth Elektronik GmbH, Schopfheim

XENON Automatisierungstechnik GmbH, Dresden

X-FAB MEMS Foundry Itzehoe GmbH, Itzehoe

X-FAB Semiconductor Foundries AG, Erfurt

Lecturing Assignments at Universities

W. Benecke
Lehrstuhl Technologie Silizium-basierter Mikro- und Nanosysteme,
Technische Fakultät, Christian-Albrechts-Universität zu Kiel

R. Dudde
Mikrotechnologien (8168),
Fachbereich Technik,
FH Westküste, Heide

H. Kapels
Elektrotechnik, Elektronik
Fakultät Technik und Informatik,
HAW Hamburg

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Mikrotechnologien (8168),
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FH Westküste, Heide

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Mikroelektromechanische Systeme (MEMS),
Institut für elektrische Messtechnik und Mess-Signalverarbeitung,
Technische Universtität Graz, Austria

B. Wagner
Lehrstuhl Prozesse und Materialien der Nanosystemtechnik, Micro- and Nanosystem Technology,
Technische Fakultät, Christian-Albrechts-Universität zu Kiel

Memberships in Coordination Boards and Committees

W. Benecke
Member of programming committees of:
- IEDM (International Electron Devices Meeting)
- EUROSENSORS
- ESSDERC (European Solid-State Device Conference)
- ESSCIRC (European Solid-State Circuits Conference)
- MST Kongress

W. Benecke
Member of Editorial Boards
- 'Sensors & Acutuators'
- Microsystem Technologies (MST)

L. Bertels
Member of Netzwerk „Qualitätsmanagement" of the Fraunhofer Gesellschaft

L. Bertels
Member of DGQ kooperative Firmenmitgliedschaft

J. Eichholz
Member of GMM/GI-Fachausschuss EM „Entwurf von Mikrosystemen", VDE / VDI-Gesellschaft für Mikroelektronik, Mikro- und Feinwerktechnik

D. Friedrich
Member of Power Electronic Region Interreg

D. Friedrich
Member of Steering Committee

P. Gulde
Member of Bundesverband Energiespeicher (BVES)

U. Hofmann
Member of Programm Committee „MOEMS and Miniaturized Systems Conference", OPTO, Photonics West,
San Francisco, 2016

D. Kähler
Nanotechnik S-H

T. Knieling
Member of Organic Electronics Association (OE-A)

T. Knieling
Technologienetzwerk Körpernahe Systemtechnik (Body Tec)

T. Knieling
Member of Organic and Printed Electronics North (OPEN)

T. Knieling
Member of Verband der Elektrotechnik Elektronik Informationstechnik e.V. (VDE)

T. Knieling
Member of IEC: TC 119 „Printed Electronics"/DKE/GUK 682.1 "Gedruckte Elektronik"

M. Kontek
Member of
AG 2.4 Drahtbonden

M. Kontek
Member of
AG2. 7 Kleben in der Elektronik und Feinwerktechnik

J. Lähn
Member of
Hamburger Lötzirkel

H.-C. Petzold
Member of Netzwerk „Qualitätsmanagement" of the Fraunhofer Gesellschaft

M.H. Poech
Member of Arbeitskreis „Systemzuverlässigkeit von Aufbau- und Verbindungstechnologie" des Fraunhofer IZM

W. Reinert
Member of Arbeitskreis A2.6, "Waferbonden", DVS

W. Reinert
Member of
„DVS-Fachausschuss Mikroverbindungstechnik"

W. Reinert
Member of IMAPS Deutschland

W. Reinert
Member of Technical Committee of Electronics Packaging Technology Conference
(EPTC)-Singapore

W. Reinert
Member of
Technical Committee of Conference Design, Test, Integration and Packaging of MEMS/MOEMS (DTIP)

W. Reinert
Member of FA 10 AVT + Löten

W. Reinert
Member of GMM Workshop Packaging von Mikrosystemen

W. Reinert
Member of Wafer Bond Technologie Konferenz

K. Reiter
Member of DGM, Arbeitskreis Probenpräparation

K. Reiter
Member of Metallographie Nord

H. Schimanski
Member of VDE/
VDI Arbeitskreis „Prüftechniken in der Elektronikproduktion"

H. Schimanski
ZVEI Fachverband Arbeitsgruppe „Zuverlässigkeit von Leiterplatten"

H. Schimanski
Member of
ZVEI Ad-hoc Arbeitskreis "Repair und Rework von elektronischen Baugruppen"

H. Schimanski
Member of
Hamburger Lötzirkel

H. Schimanski
FED Arbeitskreis „Zukunftsweisende Baugruppenfertigung"

H. Schimanski
Member of
FED Regionalgruppe Hamburg

H. Schimanski
DVS Fachausschuss FA10 „Mikroverbindungstechnik"

H. Schimanski
GfKORR Arbeitskreis „Korrosionsschutz in der Elektronik und Mikrosystemtechnik"

B. Wagner
Member of GMM-Fachausschuss 4.1 „Grundsatzfragen der Mikrosystemtechnik und Nanotechnologie", VDE/VDI-Gesellschaft für Mikroelektronik, Mikro- und Feinwerktechnik

A. Würsig
Member of Allianz Batterien of the Fraunhofer-Gesellschaft

A. Würsig
Member of AGEF (Arbeitsgemeinschaft Elektrochemischer Forschungsinstitutionen e. V.)

A. Würsig
Member of Bundesverband Energiespeicher (BVES)

A. Würsig
Member of Kompetenznetzwerk Lithium-Ionen-Batterien (KLiB)

G. Zwicker
Head of Fachgruppe Planarisierung / Fachausschuss Verfahren / Fachbereich Halbleitertechnologie und -fertigung der GMM des VDE/VDI

G. Zwicker
Member of
International Executive Committee of International Conference on Planarization/ CMP Technology (ICPT)

Cooperation with Institutes and Universities

Hochschule Bremen

Fachhochschule Bielefeld

University of Cape Town, South Africa

Technische Universität Chemnitz

Technische Universität Dresden

Universität Duisburg-Essen

Fachhochschule Flensburg

Universität Freiburg

Hochschule für Angewandte Wissenschaften, Hamburg

Helmut-Schmidt-Universität, Hamburg

Leibniz Universität, Hannover

Fachhochschule Westküste, Heide

Fachhochschule Kaiserslautern

Christian-Albrechts-Universität, Technische Fakultät, Kiel

Fachhochschule Kiel

Fachhochschule Lübeck

Technical University of Denmark, Lyngby, Denmark

Westfälische Wilhelms-Universität, Münster

Instituto Dante Pazzanese de Cardiologia, Sao Paulo, Brazil

Sydansk Universitet, Sonderburg, Denmark

Fachhochschule Wedel

Trade Fairs and Exhibitions

MD&6M West 2016, Anaheim, California USA
Medical Design and Manufacturing, International Annual Medtech Event
February 09–11, 2016, Anaheim California USA

Battery Japan 2016
International Rechargeable Battery Expo, in Cooperation with Fraunhofer Netzwerk Batterien
March 02–04, 2016, Tokyo, Japan

SSI, Smart System Integration 2016
International Conference and Exhibition on Integration Issues of Miniaturized Systems
March 09–10, 2016, München

Energy Storage 2016
March 15–17, 2016, Düsseldorf

SMT/Hybrid/Packaging 2016
Hybrid Packaging System Integration in Micro Electronics
April 26–28, 2016, Nürnberg

PCIM Europe 2016
International Exhibition & Conference, Power Conversion Intelligent Motion
May 10–12, 2016, Nürnberg

Analytica 2016
International Trade Fair for Laboratory Technology, Analysis, Biotechnology and Analytica Conference
May 10–13, 2016, München

Optatec 2016
International trade fair for optical technologies, components and systems
June 07–09, 2016, Frankfurt

Nordjob Unterelbe Westküste 2016
Trade Fair for Education and Study
July 21–22, 2016, Horst

microtec nord 2016
September 22, 2016, Heide

AzubIZ 2016
Regional Training Fair
September 23, 2016, Itzehoe

WindEnergy 2016
International Trade Fair for Wind Industry
September 27–30, 2016, Hamburg

Battery + Storage 2016
Oktober 10–12, 2016, Stuttgart

Semicon 2016
Internationale Fachmesse für Halbleitertechnik
Oktober 25–27, 2016, Grenoble, Frankreich

Electronica 2016
International Trade fair for Electronic Components, Systems and Applications
November 08–11, 2016, München

Compamed 2016
High Tech Solutions for Medical Technology International Trade Fair
November 14–17, 2016, Düsseldorf

Miscellaneous Events

Aspekte moderner Siliziumtechnologie
Public Lectures, monthly Presentations, Fraunhofer ISIT, *Itzehoe*

Workshop "Trends in Sensorik, Diagnostik und optische Messverfahren"
organized together with "Life Science Nord," a regional cluster for medical technology and biotechnology
February 11, 2016, Fraunhofer ISIT, Itzehoe

ISIT Presentation in framework of „Macht mit bei Mint – Zukunftsberufe für Frauen"
Information Day for Schoolgirls, initiated by Volkshochschulen Kreis Steinburg
February 23, 2016, Fraunhofer ISIT, Itzehoe

35. CMP Users Meeting and 6. Wet Users Meeting
April 22, 2016, Salzburg, Austria

Open Day of Hightech Itzehoe
with over twenty Companies and Research Institutions
September 10, 2016, Fraunhofer ISIT, Itzehoe

ISIT Presentation within the Framework of the Birthday Festivity for Citizens: 70 Years Schleswig Holstein
October 01–02, 2016, Eutin

36. CMP Users Meeting and 7. Wet Users Meeting
October 28, 2016, Bernin, France

Distinctions

L. Blohm,T. Knieling, E. Nebling
Ideenwettbewerb Schleswig-Holstein 2017, Sonderpreis Food&Health

V. Stenchly
GMM-Preis 2016
Gesellschaft Mikroelektronik, Mikrosystem- und Feinwerktechnik

Patents

Supplement 2015

T. Lisec, M. Knez
Method for Producing a Three-dimensional Structure and Three-Dimensional Structure
US 9,221,217

2016

E. Nebling, L. Blohm, J. Albers
Fluidische Gigaohm-Dichtung für Transmembranprotein-messungen
DE 102014111984

O. Schwarzelbach, M. Weiss, V. Kempe
A Sensor for Detecting Accelerations
CA 2 670 513

U. Hofmann, H.-J. Quenzer, J. Janes, B. Jensen
Mikrospiegelanordnung und Verfahren zur Herstellung einer Mikrospiegelanordnung
EP 2828701 B1

L. Blohm, E. Nebling, J. Albers, G. Piechotta
Integriertes Einweg-Chipkartuschensystem für mobile Multiparameter-analysen chemischer und /oder biologischer Substanzen
EP 2830763 B1

U. Hofmann, M. Oldsen
Gehäuse für in mobilen Anwendungen eingesetzte mikromechanische und mikrooptische Bauelemente
EP 2102096 B1

C. Wijayawardhana, G. Neumann, P. Gulde
Electrochemical Cell Based on Lithium Technology with Internal Reference Electrode, Process for its Production and Methods for Simultaneous Monitoring of the Voltage or Impedance of the Anode and the Cathode thereof
JP 5985486

T. Thönnessen, G. Neumann
Method for Filling Electrochemical Cells
US 9,431,648

S. Gu-Stoppel, H.-J. Quenzer, U. Hofmann
Device Comprising a Spring and an Element Suspended Thereon, and Method for Manufacturing same
US 9,399,573 B2

J. Eichholz
Verstärkerschaltung und Verfahren
DE 102010031575 B4

W. Reinert
Verfahren zum Herstellen elektrisch leitender Durchführungen durch nicht- oder halbleitende Substrate
EP 1946367 B2

G. Piechotta, H.-J.Quenzer
Chip Produced at Wafer Level for Liquid Chromatography and Method for the Production thereof
US 9,482,651 B2

T. Lisec, F. Stoppel
Mikro-Elektro-Mechanisches System und Verfahren zum Herstellen desselben
DE 102014202763 B4

U. Hofmann, H.-J. Quenzer, U.Janes, B. Jensen
Micromirror System and Method of Manufacturing a Micromirror
US 9,523,848 B2

U. Hofmann, M. Weiß
Ablenkvorrichtung für einen Scanner mit Lissajous-Abtastung
JP 6012276

P. Merz, M. Weiß
Mikromechanischer Intertialsensor zur Messung von Drehraten
EP 2937666 B1

T. Thönnessen, G. Neumann
Verfahren zum Befüllen elektrochemischer Zellen
EP 2901514 B1

Diploma, Master's and Bachelor's Theses

Benjamin Abendt
Entwicklung einer Pumpensteuerung zur Kontrolle von Reaktionsabläufen in einem Biochip-System
Bachelor's thesis, HAW Hamburg, December 2016

Helge Anderson
Atomic Layer Deposition of Al-doped ZnO- Based Conducting thin Films for Galvanic Filling of Through-Silicon Vias
Bachelor's thesis, CAU Kiel, September 2016

Finja Autzen
Entwicklung einer energieautarken Elektronik zur Leistungserfassung in Fahrradtretkurbeln
Master's thesis, FH Westküste, November 2016

Christopher Beale
Development of Electrochemical Biosensors on Flexible Substrates
Master's thesis, HAW Hamburg, March 2016

Shruti Borkar
Development of a Wearable System for Lactate Monitoring using an Electrochemical Biosensor
Master's thesis, HAW Hamburg, January 2016

Sergej Broschko
Entwicklung eines mobilen Messsystems für die Point of Care - Diagnostik mit elektrischen Multipositions-Biochips
Master's thesis, FH Westküste + HAW Hamburg, October 2016

Julian Franz
Thermische Vermessung von Li-Ionen-Zellen durch zellintegrierte Temperatursensoren
Bachelor's thesis, FH Bielefeld, June 2015

Zakaria Ben Ghalia
Softwareentwicklung für die Inbetriebnahme eines echtzeitfähigen Messsystems von NI
Bachelor's thesis, FH Wedel, April 2016

Ben Greenwalt
Integration of Organic LED and Optical Sensing to Create a Wearable Health Monitoring Device
Master's thesis, HS Bremen, September 2016

Sayli Kadambande
Optimization of a Biochip System for Point of Care Diagnostics Concerning Medical Device Regulation
Master's thesis, HAW Hamburg, March 2016

Gnanavel Vaidhynathan Krishnamurthy
Single Target Sputtering vs Co-Sputtering of Piezoelectric AlScN: Process Development, Characterization and Performance Comparison
Master's thesis, CAU Kiel, November 2016

Eirik Nagel
Untersuchung technologischer Einflussgrößen auf die Eigenschaften von integrierten ESD-Dioden in PowerMOS-Bauelementen mittels Transmission-Line Pulse (TLP) Messungen
Bachelor's thesis, FH Flensburg, April 2016

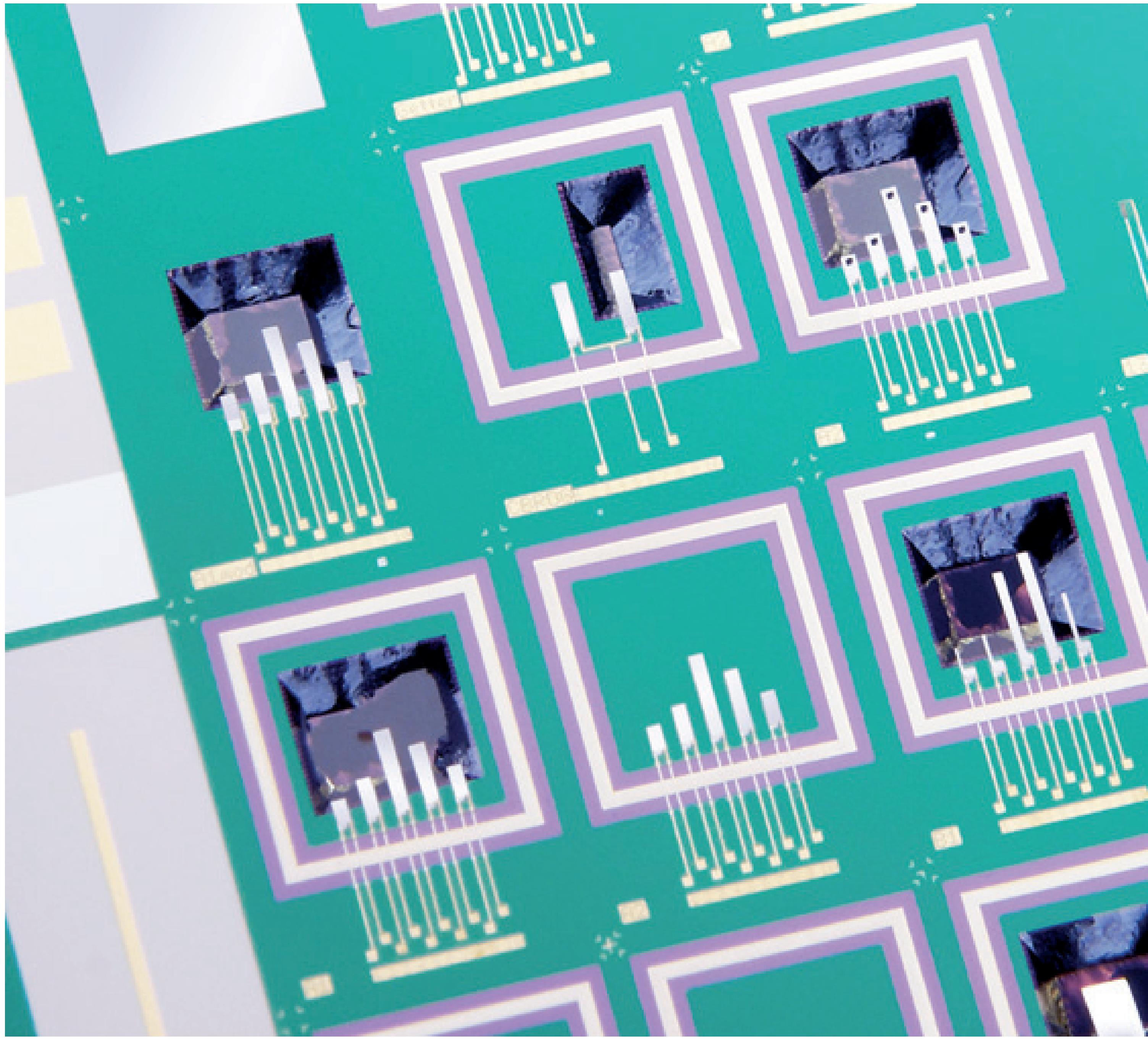
Kristina Rumler
Validierung unterschiedlicher Biochip-Kartuschen für die Point-of-Care Infektionsdiagnostik
Bachelor's thesis, HAW Hamburg, August 2016

Arne Schwinning
Entwicklung einer EMV-gerechten Platine zur Messung des Gate-Spannungsverlaufes eines IGBTs bei Schaltvorgängen in einem Tiefsetzsteller mittels ADCs im Bereich um 100MSPS
Bachelor's thesis, HAW Hamburg, October 2016

Florian Thiemann
Digistift – Entwicklung eines energieautarken digitalen Schreibstifts
Bachelor's thesis, FH Wedel, March 2016

Zhang Yimei
Mechatronische Integration eines energieautarken elektronischen Schreibstiftes
Bachelor's thesis, FH Kiel, May 2016

Magnetoelectric sensors for medical applications



Journal Papers, Publications and Contributions to Conferences

S. Fichtner, S. Bohse, N. Wolff, D. Kaden, S. Chemnitz, B. Wagner
Al1-xScxN for Piezoelectric MEMS: Interface Preparation and Stress Control.
5th International Workshop on Piezoelectric MEMS, May 24–25, 2016, Grenoble

S. Gu-Stoppel, V. Stenchly, D. Kaden, H. J. Quenzer, B. Wagner, U. Hofmann, R. Dudde
New Designs for MEMS-Micromirrors and Micromirror Packaging with Electrostatic and Piezoelectric Drive.
TechConnect Briefs, Advanced Manufacturing, Electronics and Microsystems, pp. 87–91, 2016, ISBN: 978-0-9975-1173-4

U. Hofmann, T. v. Wantoch, G. Eberhardt, I. Kinski, M. Moeser, F. Senger, C. Mallas
Dynamic Shaping of the Basic Intensity Profile of Adadptive Laser Headlights Based on Resonant MEMS Scanning Mirrors.
Proceedings of VISION Conference SIA, October 13–14, 2016, Paris

D. Kaden, F. Schmidt, A. Jakob, H.-J. Quenzer, T. Jung, F. Tiefensee, B. Wagner
Synthesis and Integration of Sputtered $Pb(Zr_xTi_{1-x})O_3$ Films of Unique Thicknesses for Ultrasound Applications.
5th International Workshop on Piezoelectric MEMS, May 24–25, 2016, Grenoble

T. Lisec, F. Stoppel, B. Wagner
Piezoelectric Ohmic Switches with Bidirectional Actuation and Improved Power Handling Capability.
5th International Workshop on Piezoelectric MEMS, May 24–25, 2016, Grenoble

T. Lisec,F. Stoppel, A. Neumann, B. Wagner
Lifetime of Bi-Directionally Actuated Ohmic MEMS Switches with Gold Contacts under Hot Switching Conditions.
Proc. MEMSWAVE Conference 2016, 5–6 July, Bucharest

C. Mallas, T. v. Wantoch, F. Senger, U. Hofmann, B. Wagner, W. Benecke
Laser Beam Scanning (pico) Projection Display Based on Resonant Micromirrors.
Proceedings Electronic Displays Conference, February 24, 2016, Nürnberg

S. Rombach, M. Marx, S. Gu-Stoppel, Y. Manoli
Low Power and Highly Precise Closed-Loop Driving Circuits for Piezoelectric Micromirrors with Embedded Capacitive Position Sensors.
SPIE MOEMS and Miniaturized Systems XV, vol. 9760, 2016

H. Schimanski
Zuverlässigkeit von Lötstellen keramischer SMD-Komponenten in Abhängigkeit von Padlayout und Lotvolumen.
Elektronische Baugruppen und Leiterplatten EBL 2016, 8. DVS/GMM-Tagung, February 16–17, 2016, Fellbach, Tagungsband pp. 140–145

H. Schimanski
Kostenoptimiertes Leiterplattendesign (Brückenschlag zwischen Design und Fertigung).
24. FED-Konferenz, Bonn, September 15–16, 2016, Konferenzband pp. 441–460

H. Schimanski
Qualifizierte Lötprofilerstellung für Reflow-, Wellen- und Selektivwellen-Lötprozesse.
24. FED-Konferenz, Bonn, September 15–16, 2016, Konferenzband pp. 571–587

S. Schröder
Erhöhung der Lötsicherheit beim Einsatz mikro- und niedrig Ag-legierter Lot in der Fertigung elektronischer Baugruppen.
IMAPS Herbstkonferenz, October 20, 2016, München

S. Schröder
Erhöhung der Lötsicherheit beim Einsatz mikro- und niedrig Ag-legierter Lot in der Fertigung elektronischer Baugruppen.
FA10, November 23, 2016, Aachen

S. Schröder
TAIKO Wafer Ball Attach.
EPTC 2016, December 02, 2016, Singapur

T. v. Wantoch, S. Gu-Stoppel, F. Senger, C. Mallas, U. Hofmann, T. Meurer, W. Benecke
Modelling of Biaxial Gimbal-Less MEMS Scanning Mirrors.
SPIE MOEMS and Miniaturized Systems, XV, vol. 9760, 2016

Z. Yu, H. Kapels, K. F. Hoffmann
Extreme High Efficiency Non-Inverting Buck-Boost Converter for Energy Storage Systems.
PCIM Europe, Nürnberg, 2016

Z. Yu, H. Kapels, K. F. Hoffmann
A Novel Control Concept for High-Efficiency Power Conversion with the Bidirectional Non-inverting Buck-Boost Converter.
EPE'16 ECCE Europe, paper 0076, 2016

S. Zabel, J. Reermann, S. Fichtner, C. Kirchhof, E. Quandt, B. Wagner, G. Schmidt, F. Faupel
Multimode Delta-E Effect Magnetic Field Sensors with Adapted Electrodes.
Appl. Phys. Lett. 108, 222401, 2016

G. Zwicker
Application of Chemical Mechanical Planarization (CMP) to More than Moore Devices. Kap. 18 in S. Babu: Advances in Chemical Mechanical Planarization (CMP), Woodhead Publishing Series in Electronic and Optical Materials
Elsevier, Cambridge, 2016

Talks and Poster Presentations

C. Beale, L. Blohm, T. Knieling, M. Fahland
Wet Etching of Gold Foils to Produce Flexible Electrochemical Biosensors.
Printed Electronics Europe, April 28, Berlin

L. Blohm
Integrated Disposable Biochip Cartridge for Point of Care Diagnostics.
COMPAMED High-Tech Forum by IVAM, 14 – 16 November 2016, Düsseldorf

L. Blohm, A. Kurylo, J. Albers, G. Piechotta, E. Nebling, T. Knieling
Electrochemical Biosensor System Integration on Flexible Substrates for Wearable Health Applications.
„Dreiländertagung" Swiss, Austrian and German Societies for Biomedical Engineering, 4 – 6 October 2016, Congress Center Basel

L. Blohm, J. Albers, G. Piechotta, E. Nebling
Integrated Disposable Chip Cartridge for Mobile Medical Analysis Based on Electrical Biosensors.
Biosensors, May 25 – 27, 2016, Göteborg, Schweden

F. Dietz
Anwendungsspezifische Hochvoltdioden für die Leistungselektronik.
Aspekte moderner Siliziumtechnologie, July 07, 2016, Fraunhofer ISIT, Itzehoe

R. Dudde
New Designs for MEMS-Micromirrors and Micromirror Packaging with Electrostatic and Piezoelectric Drive.
Nanotech 2016, Washington, MD, May 23–25, 2016

J. Eichholz
Erzeugung bewegter Bilder in 3D für die Außenwerbung.
Aspekte moderner Siliziumtechnologie, March 02, 2016, Fraunhofer ISIT, Itzehoe

U. Hofmann
Dynamic Shaping of the Basic Intensity Profile of Adaptive Laser Headlights Based on Resonant MEMS Scanning Mirrors.
International Conference VISION – SIA, October 13–14, 2016, Paris

T. Knieling, A.Kurylo, G. Domann, B. Stadlober
Moni-Shirt – Großflächige Sensortechnologien zur Erfassung von Bewegungsmustern und Gesundheitsdaten von Senioren.
4. Anwenderforum SMART Textiles, February 25, 2016, Papenburg

T. Knieling
Flexible and Hybrid Electronics: Sensor Systems and IEC Standardization Activities.
IMRC Congress 2016, Cancun, Mexiko

F. Lofink
Energy Harvester für den autarken Betrieb einer hochauflösenden magneto-resistiven Positionssensorik.
Aspekte moderner Siliziumtechnologie, April 06, 2016, Fraunhofer ISIT, Itzehoe

C. Mallas
Laser Beam Scanning (pico) Projection Display Based on Resonant Micromirrors.
Electronic Displays Conference, February 02, 2016, Nürnberg

E. Nebling
Biologie und Silizium – unmöglich?
April 15, 2016, Kaiser-Karl-Schule, Itzehoe

E. Nebling
Elektrische Biochips / Enzymbasierende Sensoren.
4. IHK Nord-Biotechnologie-Konferenz, September 22–23, 2016, Göhren-Lebbin

J. Ophey, R. Mörtel
Improvement and Characterization of Electrical Conductivity Lithium-Ion Battery Electrodes.
UECT 2016, Ulm

G. Piechotta
Biologie und Siliziumchips.
Summer Science School am IZET Innovationszentrum, September 14, 2016, Itzehoe

M. H. Poech
Werkstoffe der AVT.
ECPE Cluster – Schulung „Aufbau- und Verbindungstechnik (AVT) in der Leistungselektronik"
January 26–27, 2016, Hanau

M. H. Poech
Passive Bauelemente, Schaltungsträger, Kühlkörper.
ECPE Cluster – Schulung „Aufbau- und Verbindungstechnik (AVT) in der Leistungselektronik"
January 26–27, 2016, Hanau

M. H. Poech
AVT für Systeme kleiner und mittlerer Leistung.
ECPE Cluster – Schulung „Aufbau- und Verbindungstechnik (AVT) in der Leistungselektronik"
January, 26–27, 2016, Hanau

M. H. Poech
Fehlermechanismen.
ECPE Cluster – Schulung „Aufbau- und Verbindungstechnik (AVT) in der Leistungselektronik"
January, 26–27, 2016, Hanau

M. H. Poech
Modelling of Thermal Aspects in Advanced Power Packaging and Implications to Reliability.
ECPE Workshop „Thermal and Reliability Modelling and Simulation of Power Electronics. Components and Systems",
November 30 – December 01, 2016, Fürth/Nürnberg

W. Reinert
Modular Packaging System for Opto-Electronic Micro Devices.
EPTC 2016, November 30–December 03, 2016, Singapur

K. Reiter
Metallographische Präparation von elektronischen Baugruppen.
smartTec „Inspection Day", September 29, 2016, Itzehoe

K. Reiter
Metallographische Untersuchung von Brandschäden in der Elektronik.
50. Metallographhietagung, September 21–23, 2016, Berlin

H. Schimanski
Zuverlässigkeit von Lötstellen keramischer SMD-Komponenten in Abhängigkeit von Padlayout und Lotvolumen.
EBL 2016, 8. DVS/GMM-Tagung, February 16–17, 2016, Fellbach

H. Schimanski
Zuverlässigkeit von Lötstellen keramischer SMD-Komponenten in Abhängigkeit von Padlayout und Lotvolumen.
Viscom Technologie-Forum, June 08–09, 2016, Hannover

H. Schimanski
Untersuchung des Einflusses der elektrochemischen Korrosion auf die Zuverlässigkeit von reparierten elektronischen Baugruppen unter Verwendung bleifreier Lote und No-Clean-Flussmittelmischungen.
Hamburger Lötzirkel, July 12, 2016, Itzehoe

H. Schimanski
Results of Quality Analysis of Leadfree Electronic Assemblies Reliability and Cleanliness Conference.
September 08, 2016, Stockholm

H. Schimanski
Investigation of the Influence of Electrochemical Migration (ECM) on the Reliability of Electronic Assemblies after Rework Using Lead-Free Solders and No-Clean Flux Mixtures.
EuroCorr 2016, September 11–15, 2016, Montpellier

H. Schimanski
Kostenoptimiertes Leiterplattendesign (Brückenschlag zwischen Design und Fertigung).
24. FED-Konferenz, September 15–16, 2016, Bonn

H. Schimanski
Qualifizierte Lötprofilerstellung für Reflow-, Wellen- und Selektivwellen-Lötprozesse.
24. FED-Konferenz, September 15–16, 2016, Bonn

H. Schimanski
Qualifizierte Reworkprozesse in der Elektronikfertigung.
3. Fachsymposium Polymerverguss, October 06–07, 2016, Bremen

H. Schimanski
Untersuchung des Einflusses der elektrochemischen Korrosion auf die Zuverlässigkeit von reparierten elektronischen Baugruppen unter Verwendung bleifreier Lote und No-Clean-Flussmittelmischungen.
IMAPS Herbstkonferenz, October 20–21, 2016, München

H. Schimanski
Untersuchung des Einflusses der elektrochemischen Korrosion auf die Zuverlässigkeit von reparierten elektronischen Baugruppen.
Aspekte moderner Siliziumtechnologie, November 02, 2016, Fraunhofer ISIT, Itzehoe

S. Schröder
Frauen in Naturwissenschaft und Technik.
April 06, 2016, Fachhochschule Westküste, Heide

V. Stenchly
Wafer aus Glas – Innovative Glastechnologien auf Waferebene.
Aspekte moderner Siliziumtechnologie, October 05, 2016, Fraunhofer ISIT, Itzehoe

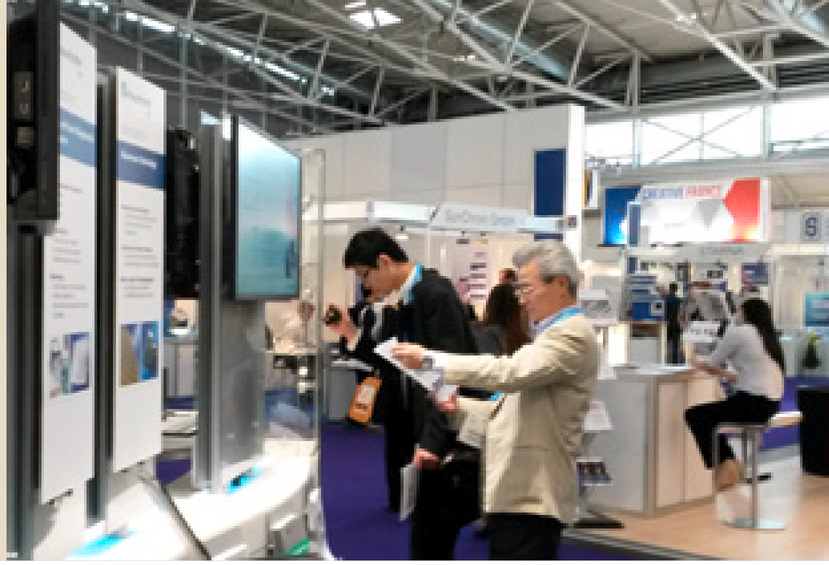
A. Würsig
Hochleistungsakkumulatoren für die Elektromobilität.
Aspekte moderner Siliziumtechnologie, June 01, 2016, Fraunhofer ISIT, Itzehoe

A. Würsig
Safety Evaluation in E-mobility: Absuse Scenarios, Testing and Mitigation.
Putting Science into Standards (PSIS) Workshop 2016, Petten, Netherlands

A. Würsig
High Power Lithium Batteries for the E-Mobility.
Round table on Electric Mobility, 2016, Porto, Portugal

A. Würsig
Direct coating of separator on electrode foils.
IMLB 2016, Chicago

Z. Yu
Hocheffizienter DC/DC-Wandler mit hoch- und tiefsetzender Funktion zur leistungselektronischen Kopplung von Energiespeichern.
Aspekte moderner Siliziumtechnologie, May 04, 2016, Fraunhofer ISIT, Itzehoe



General View on Projects

Power Electronics

- Fraunhofer Anwendungszentrum Leistungelektronik für regenerative Energiesysteme, ALR, Standort Hamburg – ALR
- Netzwerk Leistungselektronik, Netzwerk LE
- Schaufenster intelligente Energie, Systemdienstleistungen mit Speichern – NEW 4.0, TV 3.7, SDL
- Entwicklung von EPI-Prozessoren für Power-MOS – EPI-Entwicklung
- Herstellung von Kupfermetallisierungen auf Leistungsbauelementen mittels kaltaktiven Atmosphärenplasmas – Herkules
- Integrierte Umrichter für modular verteilte Elektroantriebe hoher Drehzahl; Teilvorhaben: Simulation, Technologische Sonderprozesse und Zuverlässigkeitsuntersuchungen für integrierte Umrichter – InMOVE
- Optimierungsphase Fast Recovery Diode – Fast Recovery Diode
- Prozessierung von Si-Substraten – TESAT-Diodencharge
- Development of Trench Based 600 V Punch Through and Field Stop IGBT´s – PT-IGBT´s Vishay
- Testung dreier Anodenkomposite – Anondenkomposite Test
- Research Report on Advanced Battery for Wearable Device – Battery Study
- Studie zur Auslegung und Bewertung einer druckneutralen Lithium-Akkumulatorlösung im Vergleich zu bestehenden ThyssenKrupp Marine Systems Konzepten – CCI-Studie
- Umweltfreundliche Hoch-Energie-NCM 622-Kathoden mit optimierter Speicherkapazität – HiLo
- Schnellladefähige Lithium-Energiespeicher mit verbesserter Energiedichte für den Einsatz in modularen Unterstützungs- und Antriebskonzepten – HiPoLit
- Batteriefolie mit Kohlenstoff-Kontaktschicht – KoKon
- Entwicklung und Herstellung von wiederaufladbaren Magnesium-Schwefel-Batterien – MagS
- Produktionstechnik für die Herstellung von Lithium-Zellen – ProTrak
- Entwicklung temperatur- und sicherheitsoptimierter Batteriemodule mit zellinternen Sensoren – TopBat

Micro Manufacturing Processes

- Entwicklungssupport von 400 µm dicken Glas-Silizium
- Weiterentwicklung von 400 µm dicken Glas-Silizium Verbundwafern mit Si-Durchführungen – 400 µm Wafer
- Silicon Baseplate Wafer – Aloha
- Herstellung freistehender MEMS-Strukturen – Amorphes Silizium
- Development of an AuIn Bond Process – AuIn Bond Process
- Waferprozessierung zur Fertigung von Aperturplatten – CMOS 256 II IMS Nano
- Herstellung von Wafern mit MEMS-Elektroden – Condias-Wafer
- Integration von Cu-Sn-Cu Bondrahmen und Kontakte auf vorprozessierte 8-MEMS und ASIC-Wafer – CU-Sn-Cu Bondrahmen
- Optimization of Gold Top Electrodes Wrt Vertical Edge Slope – Gold Top Electrodes
- Glass Silicon Cap Wafer – Lantern
- Implementation of an 3D Accelerometer Sensor Process for Panasonic – Popeye
- Process Screening of Resist Shaping by Melting Process for Refractive Lens Shapes – Refractive Lens Shapes
- Development of a Process to Transfer a Resist Shape into a Silicon Shape – Resist Shape
- Qualifikation von zwei Starr-Flex-Leiterplattenaufbauten – Starr-Flex-LP
- Magnoelectric (ME) Stack on PDMS, WP 1 – Study ME on PDMS
- Post-Processing von TROM2 CMOS Wafern – TROM
- Herstellung von 400 µm dicken Glas-Silizium-Verbundwafern mit Si-Durchführung – Verbundwafer
- Verbundvorhaben: Waferbasierte 3D-Integration von IR-Sensor-Technologien - Teilvorhaben: Waferlevel-Packaging von Thermopile-basierten Infrarot-Detektoren – Win-IT
- Development of Process Modules for WLP of Microphones – WLP of Microphones

MEMS Applications

- Development of 2D-MEMS-Scanning Mirror – 2D-MEMS-Scanning Mirror
- Entwicklung neuartiger, temperaturstabiler und dampfdichter Miniaturkameras – AIF-ZIM Miniaturkamera
- Multi-Energy-Harvester für den autarken Betrieb einer hochauflösenden und hochkompakten MR Positionssensorik – Verbundvorhaben AQUILA, Teilprojekt ISIT
- Mikrotechnisch aus Silzium gefertigter zweiachsiger MEMS-Scanner zur Ablenkung von Laserstrahlen – AR-VR-MEMS-Scanner
- Bio Energetic Micro Operation Unit – BEMOU
- Entwicklung eines hochintegrierten digitalen Hochleistungsbelichters für die Belichtung von Lötstopplacken – DAHLIA
- Magnetoelektrische Sensoren für medizinfrequenzmodulierte magnetoelektrische Sensorsysteme zur Messung breitbandiger, niederfrequenter biomagnetischer Felder – DFG-Biomagnetische Felder
- Magnetoelektrische Sensoren für Medizin-Sensorsysteme auf Basis des DeltaE-Effekts – DFG-DeltaE-Effekt
- Magnetoelektrische Sensoren für medizinresonante magnetoelektrische Sensorsysteme zur Messung der tiefen Hirnstimulation – DFG-Messung der Hirnstimulation
- Energieautarker digitaler Schreibstift für den Schulunterricht; Teilvorhaben: Energieautarke Umsetzung eines digitalen Schreibstifts mit Inertialsensorik – DigiStift
- Elektrische Array-Chips – eBiochips
- Service Processing Annealing Wafers – Energy Harvester Processing
- Akustische Gang- und Laufanalyse – Ganganalyse
- Industrietaugliche UKP-Laserquellen und systemweite Produktivitätssteigerungen für hochdynamische Bohr- und Schneidanwendungen – InBus
- MEMS-basiertes Laserstrahl-Ablenksystem für einen Laser-Projektions-Scheinwerfer – KOLA
- Vorbereitung von MEMS-Spiegeln und AnsteuerElektronik sowie Durchführung von Labor-Experimenten – LDT-MEMS-Spiegel
- Machbarkeitsstudie LIDAR-MEMS-Scanner – LIDAR-Studie
- Entwicklung einer integrierten Schaltung zur Motoransteuerung von Schrittmotoren mithilfe externer Leistungstransistoren -MANATEE
- Entwicklung eines kombinierten Sensors zur Messung und telemetrischer Übermittlung zweier orthogonaler Kräfte und zweier orthogonaler Beschleunigungen – MECHASENS
- Piezoelectronic MEMS Loudspeaker – MEMS Loudspeaker
- Fabrication of 3000 Additional MEMS Scanning Mirror s – MEMS Scanning Mirrors
- Process Module Development and Sample Fabrication of Piezoelectronic MEMS-Microphones – MEMS-Microphones
- Herstellung von MEMS-Scannern und eines darauf aufbauenden Laser-Projektions-Display-Demonstrators – MEMS einschließlich eines Musters von MEMS-Scannern mit Ansteuerelektronik – MEMS-Scanner
- Mobiles In-Situ Belastungs-Monitoring von mechanischen Bauteilen aus Faserverbundwerkstoffen – MobiMo
- Medizinische Bewegungsanalyse mit Hilfe körperkonformer, großflächiger Sensorik – Moni-Shirt
- Process and Design Improvement of Piezo-electronic Microspeakers – Optimierung Lautsprecher
- AuIn WLP, Project Plato – Plato
- SEM- und FIB-Analysen sowie elektrische Messungen an PEV-Wafern – SEM/FIB-Analysen
- Resonant magnetoelectric sensors – SFB 1261-A3
- MEMS Magnetoelectric Sensor Fabrication – SFB 1261-Z1
- Si-Cap Top and Bottom for Single die Tooling 600 Hz Harvester – Si-CAP HARVE
- Entwicklung eines MEMS-Scanners – Valeo MEMS-Scanner

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