IMMS

Annual Report 2009

Imprint

Publisher
Institute for Microelectronic and
Mechatronic Systems GmbH

Editing and Proof Reading
Prof. Dr.-Ing. Ralf Sommer
Dipl.-Ing. Hans-Joachim Kelm
Dipl.-Medienwiss. Ines Lehrke
Manuel Mohr
Tina Schmidt

Layout and Composings
Manuel Mohr
Tina Schmidt
Dipl.-Medienwiss. Ines Lehrke

Translation
Dr. David Kirya

Pre-press
Frank Diehn • www.fRanKon.de

Printed by
Brandtdruck e.K.
Mittelstraße 9, 98714 Stützerbach
www.brandtdruck.de
info@brandtdruck.de

Photos
Dipl.-Kffr. Stefanie Theiß
www.pixelio.de

Contact
Dipl.-Medienwiss. Ines Lehrke
PR / Marketing Manager
Ehrenbergstr. 27, 98693 Ilmenau
Phone: +49 (3677) 69 55 13
Fax: +49 (3677) 69 55 15
E-Mail: imms@imms.de

May 2010

„It is crucial that the interdependent growth aspects of modern technological developments are also holistically reflected in the design process. The IMMS strives to build on the coherence of such existing competencies and synergies in as far as they result in the generation of maximum customer benefit. We thus serve you with an all encompassing platform for the future of your products.“

Prof. Dr. Ralf Sommer, Scientific Director of the IMMS GmbH
Dipl.-Ing. Hans-Joachim Kelm, Commercial Director of the IMMS GmbH

Contents

Contents


© Willi Heidelbach / PIXELIO

The Institute

Preface

Dear Business Partners, Dear Friends, Ladies and Gentlemen,

The IMMS looks back on an eventful but nevertheless successful year 2009.

The year was characterized by an unfavorable overall economic situation and has also not passed without leaving a trace on the IMMS. All the more was it important for us, as will also be the case in the future, to acquire public and industrial projects and to jointly implement them profitably.

We have met the challenge and will continue to enforce this process even further in 2010. We will also continue to focus and strengthen our overall research and development capabilities and to center the focus of our work more towards the benefits for the user.

„We have met the challenge and will continue to enforce this process even further in 2010.“

Through intensive research and development work in all areas, we have been able to achieve results that make us proud. Together with our partners from the public and industrial sector, important projects have been implemented and launched.

The IMMS was thus together with the Ilmenau University of Technology in the BMBF project SYENA, able to be very successful through many contributions and especially with a new method for automated switching topology modification for high-performance integrated analog switching.

Also a project part under the framework of the excellence cluster „Cool Silicon“ was approved. The Cool Silicon Cluster – with more than 60 companies and research institutions – focuses on three key projects relating to the subjects CoolComputing, CoolReader and CoolSensornet. The approved sub-project has set itself the goal of exploring energy-efficient sensor networks for acoustic condition monitoring. Experts of the institute will focus on the software platform for energy management.

The IMMS also looks back concomitantly with self-confidence on the successful completion of the project „Multiaxial direct drive systems with modular, networked control“ within the regional growth core program VERDIAN. The vision of the regional growth core program to be a leading global provider of magnetic direct drives by 2015 was taken forward by a large step with the help of a sub-project that entailed the involvement of the IMMS. The research and development work of the IMMS was characterized by the application of an integrated mechatronic design for direct drives taking into account new functional structures, magnetic materials and production technologies as well as real-time controllers with new control and feedback algorithms as well as integrated metrology. Numerous results from all areas of the IMMS have emerged from this project: a scalable multiple coordinate drive, a magnetically guided table and an optical 3D-measurement head with EtherCAT® interface.

We do not want to only draw on hitherto successes, and we will therefore not tolerate any standstill. It is also becoming increasingly important for the IMMS to explore new task fields and we strive through cooperation in various fields of technology to not only attain technological excellence, but to also attain a clear added value for the users of our developments. We thereby rely on our growing partnerships to research institutes and both regional and supraregional based companies. We offer know-how transfer and innovative market-near developments.

The collaboration with the Fraunhofer Institute for Integrated Circuits IIS in the field of design methodology, as well as with the Fraunhofer Institute for Biomedical Engineering IBMT in the field of microelectronics in medical technology are examples of a close link between the different fields of competence that extend beyond the institute's boundaries.

„ It is also becoming increasingly important for the IMMS to explore new task fields and we strive through cooperation in various fields of technology to not only attain technological excellence, but to also attain a clear added value for the users of our developments."

The regional networks are thereby also strengthened through increased cooperation. Work within the ELMUG cluster (Electronic Measurement and Device Technology in Thuringia) for example, received a new quality, which is also reflected in the authorization of the successor project to the regional growth core project SHS (Smart Home Services). Last but not least strong and established structures in the cooperation with industry partners such as the TETRA GmbH or Heinz Messtechnik GmbH have led to transfers of IMMS-research into marketable products.

Our hitherto successes are concomitantly to be regarded as a reward and incentive. Based on this the IMMS will continue to enhance its regional, national and also international links with industry and academic partners, in order to convert them to solid research and development results and to achieve a technological advantage for our partners.

The project completed in 2009 with the company Advanced Laser Separation International N.V. (ALSI) and the Institute Center for Concepts in Mechatronics B.V. (CCM) in the Netherlands, whereby the IMMS developed the planar motor PMS 380, testifies the focus of the institute to reach beyond national borders. But also in international research projects such as the EU project SMARTIEHS (Smart Inspection System for High Speed and Multifunctional Testing of MEMS and MOEMS); the IMMS was able to credibly prove itself.

The strategic expansion of our research portfolio is successively and in accordance with the solutions of specific industry requirements being stretched to new frontiers. Of course we also build on the excellent cooperation with the Ilmenau University of Technology, which provides an enormous enrichment and support to our work. We are thankful for this ever-growing and strong attachment to the University and hope also in the future to count on the results of the synergy effects that go beyond the combination of our research topics across various scientific disciplines.

The continuous development of the IMMS is also evident in the numerous scientific publications and presentations. We were honored with the Best Paper Award at the Cadence CDNLive! 2009. Numerous filed patent applications also attest to the ingenuity of our employees. The IMMS was for example honored at the International Specialist Exhibition Ideas-Inventions-New Products IENA 2009 with a silver medal for the „development of customized linear motors".

The vision of the IMMS is carried and natured mainly by the full commitment of our employees. Beyond the professional know-how it is also the teamwork and interpersonal skills that are the cornerstones of our work.

Through the continuous commitment and own initiative, the project management of the IMMS was for example promoted by our employees, to a new level that enables us to provide for our customers also in the coming years, the best development work possible.

„The vision of the IMMS is carried and natured mainly by the full commitment of our employees.“

Equally important is the promotion of IMMS teams in the institute: the personal development is hereby supported through various ways and means. In 2009 language and communication courses were offered and also in future soft skills will similar to professional skills, be the focus of IMMS-further training.

As in previous years, the Institute will continue its efforts to in the best way purposefully support young scientists and to introduce them at an early stage to research and development. The IMMS wants to pave the way to practice for students just as well as for graduates and post-graduates.

All this would not be possible without our partners.

Our thanks go to the Free State of Thuringia. Its support of a strong research landscape and research networks benefits also the IMMS.

A word of grateful thanks is also extended to all business partners, friends, supporters and people for backing us.

At this point we would like to also thank the Scientific Advisory Board of the IMMS, which is supportive to us in all matters and stands by our side in an advisory capacity.

The Institute consistently pursues the goal of efficiently transferring research results into new products, processes or services. With creativity, commitment and high dedication the whole team contributed to this end with professional expertise and personal skills. For the constructive and trusting relationship in the past year, we would like to expressively thank in a special way all employees of the IMMS. Only through them can we achieve our ambitious future goals.

On the following pages of our annual report, we want to exemplary not only present to you the new paths the IMMS has ventured to embark on, but to also portray how certain already known paths have been improved.

Prof. Dr. Ralf Sommer

Dipl.-Ing. Hans-Joachim Kelm

Profile

IMMS – Profile of the Institute

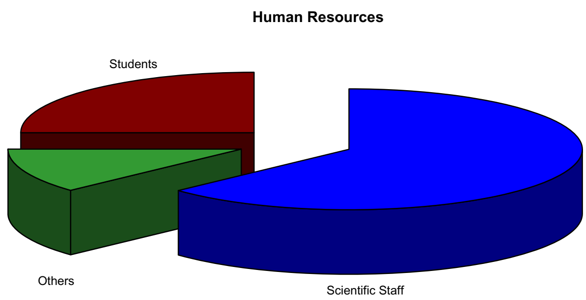
Under the direction of Prof. Ralf Sommer (PhD Eng), and Mr. Hans-Joachim Kelm (M.Sc Eng) the Institute has developed micro-electronic and mechatronic systems and devices as well as the necessary circuitry, software and design methods. The headquarters in Ilmenau/Thuringia – on the campus of the Ilmenau University of Technology (TU Ilmenau) – allows the Institute to exploit both its location as well as its position as an affiliated institute of the TU Ilmenau, to build strong linkages with the academic research environment. The other location in Erfurt is with regards to infrastructure equally well established and is located in the southeast of Erfurt – the center of microelectronics and photovoltaics Thuringia and in close proximity to companies such as X-FAB, Melexis, PV Silicon and Er-Sol Solar Energy.

Human Resource development

101 employees worked at the IMMS in 2009. Of these, approximately 87 percent were employed in research and development – 63 scientists and 25 students (Full Time Equivalent).

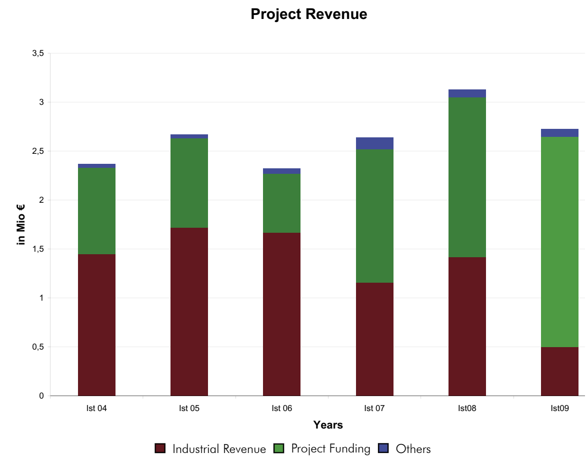
As in the past years, a large number of students (a total of 58) took advantage of the offer extended by the IMMS, to further and complete their education through applied research: 42 students completed internships and further ten their "diploma" theses, five bachelor theses and five master theses were supervised. Seven employees are also currently enrolled as doctoral students at a university.

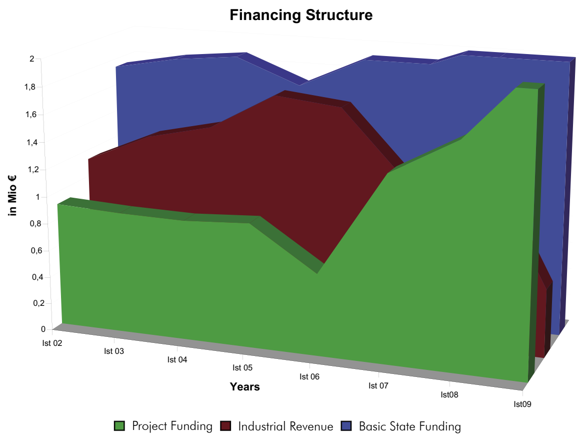
The IMMS is also proud of the fact that in 2009 a trainee successfully completed vocational training as an office clerk and that a new trainee could be engaged within the administrative department. Overall, the IMMS currently supervises three trainees.



Financing

Project income from industrial contract research has declined by about 60 percent as a result of the current world economic crisis, whereby the cooperative work with partners from the mechanical engineering and microelectronics sector has in particular been affected. At the same time revenue from public projects could nevertheless be significantly increased. This is on the one hand partly attributed to the successful acquisition in 2008. On the other hand this development however reflects the current political policy that is focused on an attempt to attain continuity in research and innovation in order to be able to provide industrial companies with all the possibilities that enable them to concentrate on the development of new products, processes and technologies. This support is as such intended to enable them to not only successfully master the period after the crisis, but to also strengthen their competitiveness with respect to the high dynamic economic development expected to subsequently follow.





Since 2007, a time of strong economic growth, the financing of the institute has undergone a dynamic change. During this period the basic funding by the state of Thuringia proved to be the guarantor of the stability of research programs in the IMMS. The positive development with respect to project funding reflects the acceptance of the IMMS as a research partner. Almost all of these projects are of a collaborative nature. The IMMS has accordingly been able to subsequently enhance the visibility of its network activities.

Although the decline in industrial contract research will not be permanent, it nevertheless poses a major challenge for the IMMS, since income from this activity is intended to finance loss-making publicly-funded projects.

Through its outstanding engagement in student education, the IMMS was able to win over enough graduates to ensure the necessary number and quality of scientific staff. It was thus possible to process the growing number of publicly funded research projects.

Scientific and Technological Orientation

The IMMS has since its foundation in 1995 been a provider of systems technologies – in the real sense and spirit of „High-Tech Strategy for Germany“.

At the core of the strategy of the IMMS are the solution concept and the satisfaction of the customer. With multidisciplinary expertise, we create innovative results on the cutting edge of research and implement them in collaboration with our manufacturing partners. We thus build technology and design methodology bridges between the different domains of an overall system and concomitantly combine the technology sector with the application – the university with the industry.

The IMMS covers all stages of the design process, from the idea and the design, over the individual assembly components and assembly groups to system integration, and ultimately to the prototypes. The Institute is in the position to contribute to the customer orientated service profile of Thuringia and to drive this forward. The focus is thereby on future-oriented key technologies, such as microsystems technology and electronics, nanotechnology, automotive engineering and optics.

Objectives

Our local expertise and specialist knowledge in various areas are combined into an overall system, which produces the best possible customer value.

The profile of the IMMS is characterized by the idea of an application-oriented implementation of scientific ideas and theoretical knowledge to develop innovative concepts, software, devices and systems.

Proven Problem-Solving Skills

Our offer that covers research, development and service, ranges from deep problem analysis over potential solution identification to the prototype.

The IMMS provides research and R & D services alike. The professional competencies are thereby focused on areas such as:

Integrated circuit technology and micro-mechanics

- RF-circuit design
- Optoelectronics
- High temperature circuit technology
- Analog precision circuit design
- Sensor-interfaces
- Pulsed electronic ballasts for gas discharge lamps

Precision drive technology

- Drive systems for high precision and vacuum use
- Analog and pulsed power assembly groups for mechatronic drives
- Analysis equipment and instruments

Model-based design technology

- Model based design, using MATLAB/ Simulink, different UML tools, ASCET-SD, VHDL, VHDL-AMS, Verilog and SystemC
- Modeling, simulation and optimization of electronic assembly elements and circuits, including symbolic analysis and design centering
- Innovative design methodology for integrated analog and mixed-signal circuits
- Compilation of design kits
- Design, selection, dimensioning and integration of air bearings, air ducts, magnetic bearings, magnetic guides
- Design and simulation of feedback for complex, high-precision mechatronic systems
- Modeling, simulation, layout and construction of product-specific magnetic actuator and mechanical precision systems
- Thermal optimization of assembly groups

Control and communication technology

- Buses and networking of systems (embedded communication, sensor networking)
- Sensor near-signal processing
- The use of free operating systems for embedded applications
- Software architectures for embedded systems
- Real-time control of actuators
- New communication technologies (wired, wireless)

Test Methodology/Test Platforms

- Simulation, test and characterization of MEMS
- Modal analysis and harmonic analysis of device structures (metrological and simulative)
- RF characterization of assembly components and IP blocks in new semiconductor technologies as well as noise measurement
- RF circuit development and RF board design among others for tester load boards
- Characterization of optoelectronic circuits with a specialized focus on dynamic characteristics
- Test methodology for quality assurance in the semiconductor industry
- Test methodology for the high temperature range up to 300 °C
- On-wafer high voltage measurement technology up to 1000 V
- Modular tester platforms

The areas in the development and manufacturing process that we have not directly established in the institute are covered by the strong partner network of the Institute, which enables us to ensure the complete implementation of the development chain.

Partner and Strategic Networks

© Konstatntin Gastmann / PIXELIO

The Institute contributes to the expertise in the fields of electrical engineering and electronics, optics, machinery, automotive, information and telecommunications technology, and logistics that serves to strengthen the medium-sized dominated industry and to underpin the settlement strategy of the State Development Corporation of the Free State of Thuringia (LEG Thüringen). With our know-how we are able to cover the entire value-added chain in the electronics and electrical engineering industry, from the assembly elements in the high-tech chip production of complex electronic and opto-electronic components to their applications in automation technology, test and measurement systems, or in control and feedback technology systems. Competition in the leading markets for new technologies has rapidly intensified. The so-called innovation cycles – the time from the formulation of ideas to their implementation in to marketable products – are becoming increasingly shorter. In addition, the growing complexity of research contributes to the need for enterprises to seek external assistance. In light of today's knowledge explosion, it will no longer be possible for individual companies to keep up, only with the help of internal research and development. True to the motto „together we are strong," it is becoming more and more important that stakeholders from academia and industry join forces. The IMMS has for years been actively involved in the initiation and organization of regional/supraregional and cross-industry clusters of respective fields of technology. In Thuringia these are cluster initiatives like OptoNet, Electronical Measuring and Machinery Technology (ELMUG), automotive thüringen (at), Automotive Cluster East Germany (ACOD), Logistik Network Thuringia, SpectroNet, and Micro-Nanotechnology-Thuringia (MNT). An example of a successful supraregional partnership is presented here: The IMMS GmbH is since 2004, a member of Silicon Saxony e.V.

SILICON SAXONY®
MY FAVORITE PLACE

It is the largest industrial association in the microelectronics sector in Europe and regards itself as a network of semiconductor, electronics and the microsystems industries. Microelectronics is the basis of innovation for many technical applications. Progress in the automotive manufacture, the computer industry or electronics is only possible as a result of the aforementioned microelectronics sector.

Silicon Saxony offers under its roof, member- and specialist forums in which trends and requirements of the microelectronics industry are discussed. At the same time, the workgroups serve as motors for the development of new technologies and procedures for the initiation of cooperative projects and the formation of bid consortia. As a result of close cooperation within the association new innovative application orientated clusters, such as „RFID Saxony" and „Dresden Fab Automation" have already been formed.

IMMS has made its competencies available to the following workgroups of the Silicon Saxony e.V.:

RESEARCH AND DEVELOPMENT

Objectives of the workgroup "research and development" are:

- Initiatives for the representation of current and future development trends

- Support by the initiation of cooperative projects

RFID SAXONY

The goal of the RFID network is to advise users of RFID (Radio Frequency Identification) and to render assistance in the introduction of the latter.

IC-DESIGN

Support by the settling or establishment of other IC Design Centers.

- **TIS (Test Integrated Systems)**

The workgroup "TIS" deals with aspects of engineering and science specific education and training of specialists, the industry-specific qualifications in higher education, as well as relevant research and development services in the field of test and evaluation of electronic assembly components, assembly groups and Microsystems (MEMS).

- **SIS (Smart Integrated Systems)**

The workgroup "Smart Integrated Systems" addresses the trend towards increasingly smaller multi-functional, self-organizing systems with interfaces for communication with the outside world.

SATNav Saxony

Satellite navigation provides the basis for a variety of new and innovative products and services. The workgroup „SatNav Saxony" is focused on the targeted preparation and use of the satellite navigation system GALILEO.

PHOTOVOLTAICS

The aim of the workgroup "photovoltaics" is to make the broad experience from the semiconductor industry, also more accessible to the new solar equipment manufacturers and producers.

COOL consens

Energy Efficiency Innovations from Silicon Saxony – Excellence Cluster

The Cool Silicon Cluster is one of the research and development projects sponsored by the Federal Ministry for Education and Research within the framework of "The excellence cluster competition". This cluster entails more than 60 companies and research institutions in Silicon Saxony. The main focus of the research is centered on three lead projects: CoolComputing, CoolReader and CoolSensornet. The competencies of the IMMS are in demand (figure 1).

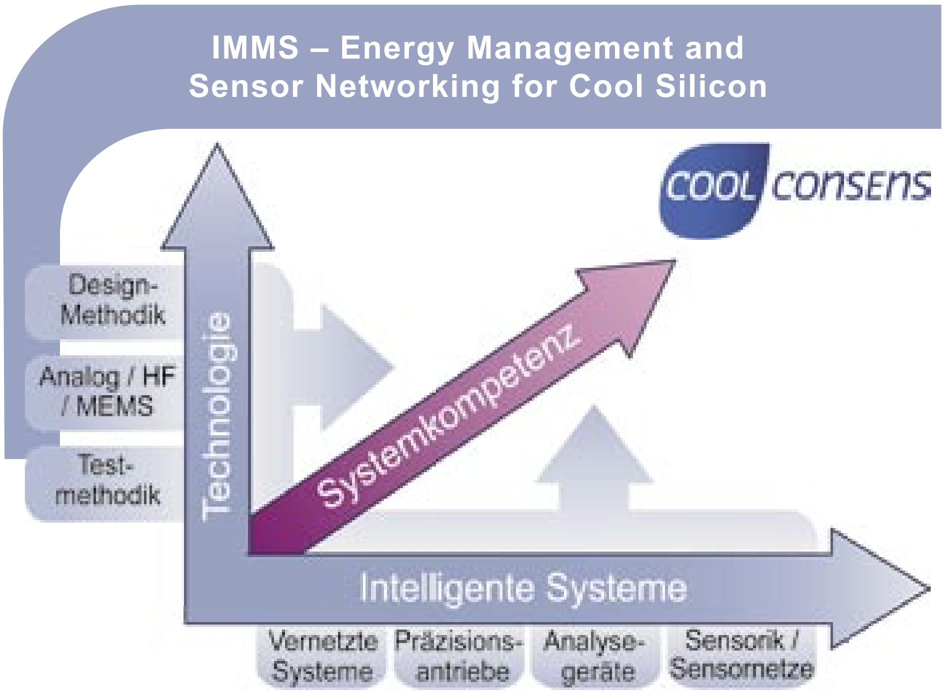


Figure 1: Energy management for acoustical configuration monitoring in „CoolConSens"

With this research project, Cool Silicon can count itself as one of the international leaders. It will serve to strengthen the global competitive position of the companies. Besides, whereas the system competence of the cluster is also being further expanded, it also ensures the long-term international determining position of the location with respect to the key technologies of energy efficiency in electronics.

In Thuringia mostly small and medium-sized companies benefit from the close and fruitful collaboration of industry and research.

Important research areas in Thuringia, such as optical technologies for energy efficiency, alternative drive systems, medical technology, technologies renewable energy resources and life sciences have been designated for the next few years.

Synergies between Saxony and Thuringia research landscapes are unmistakable.

Through competence networking of science and industry in both federal states, technical, economic and environmental performance can be implemented even more effectively, joint market development strategies developed and new business models concluded.

We will strive to make a significant contribution to the achievement of this goal.

Quellen

www.silicon-saxony.org
www.cool-silicon.com
www.smartsystemintegration.com

Dr.-Ing. Wolfgang Sinn, Business Development Manager, wolfgang.sinn@imms.de

Institute Life at the IMMS

SKATING at the IMMS

SKATING stands for study and career preparation with the Ministry of Education and Culture, Ministry of Economy, Chamber of Commerce and Industry, the Erfurt Chamber of Skilled Trades and the Thuringia employment agency in high schools. The project kicked off at the beginning of the school year in 2009, at nine high schools in central Thuringia with a total of 974 students.

The IMMS participated in lectures at the Heinrich-Mann High School and the Erfurt Integrated Comprehensive School within the framework of the initiative SKATING. The goal was to make high school students in the higher classes more versed in particular with the theme of microelectronics. To this end tours as a basis for further development were organized in the Erfurt division of IMMS and the X-FAB, so that the students could also get more conversant with the industrial center „Microelectronics" in Erfurt. Under these auspices the microelectronics department of the IMMS located in the research and industrial center in Erfurt-Southeast received students from the 10th and 11th grades.

High school students visiting the IMMS in Erfurt

The youngsters were led through the rooms of the IMMS and had the opportunity to use an 18 m long Foucault pendulum to put their knowledge of physics to the test with regards to the earth's rotation and the Coriolis force (inertia force).

Many took advantage of the opportunity on site, to ask questions about relevant professional careers or study fields and showed a keen interest in the manifold applications of microelectronics in everyday life.

Art Exhibition „Hangover Breakfast"

On 15 June 2009 the opening of the art exhibition „Hangover Breakfast" took place within the premises of the IMMS Ilmenau.

„Password Spring"

The artist Uta Melletat exhibited illustrations and collages that wrap stories drawn from reality in a cloak of fantasy and easiness. In addition to her work as a freelance artist, the graduate graphic designer who was born in Leipzig also lectures design at the Walter-Gropius-School in Erfurt.

IMMS Children's Feast

In summer, the Institute again held the annual IMMS Children's feast for all employees and their families.

On the sports field of the Ilmenau University of Technology a bouncy castle and many other games and fun stations were provided for the little ones – there was not only a large playing cloth, various race competitions such as the egg and spoon

Group shot at the children's feast

race, running races in rubber boots and partner running, but the program also entailed Bobby car racing. A parent-puppet show featured the „The Frog Prince", the children could paint their faces and an ice cream van provided for the necessary cooling. For the very young there was a separate play area and in the course of the afternoon also several further surprises. Culinary wishes were also best catered for with Thuringia sausages and soft drinks.

Talks about the Future of Microelectronics

On 25 September 2009 the former President of the Thuringia Federal State Parliament Prof. Dr. Dagmar Schipanski visited the IMMS; in whose founding Professor Schipanski had been significantly involved. The focus of the talks that were accompanied by guided tours through the labs, and presentations of the individual areas of expertise was on the hitherto and future development of microelectronics in Thuringia.

The visit to the Institute was also attended by partners from the industrial sector. Olaf Mollenhauer (Managing Director of the TETRA GmbH), Dr. Herwig Döllefeld (Innovation Manager of the X-FAB AG) and Helmut Heinz (Managing Director of H. Heinz Resistors GmbH) discussed current challenges facing the electronics industry with the IMMS and Professor Schipanski.

During the tours of the research laboratories Professor Schipanski was able to gain an insight in the latest developments in the field of modular test platforms, embedded systems, the planar precision drives as well as in current industry research.

Long Night of Science Erfurt

On 6 November 2009 the „Long Night of Science" was once again held in Erfurt. For the second time the branch of the IMMS Institute located in Erfurt also took part. The IMMS presented in the foyer of the Microsystems Technology Application Center (AZM), both the Foucault pendulum, as well as exhibits from the area of system design – specifically, these were the IMMS Concept Truck, the Light Shooter and a speed sensor. The CiS offered guided tours and insights into the area of MEMS/MOEMS, and showed exhibits in

Professor Schipanski in talks with Dr. Schäffel

Guests at the „Long Night of Science"

cooperation with various other partners such as the virtual test lab Climate Test Center with TÜV as well as with the Optolab association and the SolarInput association.

Over 320 visitors – from four to 64 years – found their way to the AZM. They thereby not only showed keen interest in technical discussions and the scope covered by the IMMS in general, but also with much pleasure tested their marksmanship on the Light Shooter, their reaction time on the speed sensor and one or the other also opened the transport box of the IMMS Truck.

Appointment of Prof. Dr.-Eng. habil. Hannes Töpfer

Prof. Sommer and Mr. Kelm congratulate Prof. Töpfer

On July 1, Dr.-Eng. habil. Hannes Töpfer was appointed as a University Professor in the Department of „Electromagnetic Theory" in the Faculty of Electrical Engineering and Information Technology at the Ilmenau University of Technology (TU Ilmenau). Professor Töpfer has been working in the IMMS since as early as 2002, where he headed from 2004 to 2009 the subject area of system design with great dedication and success.The appointment of Professor Töpfer opens up further opportunities for the development of intensive cooperation between the IMMS as an affiliated institute of the University and the TU Ilmenau. Professor Töpfer will direct the research work at the Institute of Theoretical Electrical Engineering to the respective physical principles and mathematical procedures that can usefully be incorporated in the solution of problems in electrical engineering. It is his intention to hereby establish clear applications and practical relevance. In order to improve the transfer of research results, the department of „Electromagnetic Theory", headed by Professor Töpfer has to this end already agreed with the IMMS on the establishment of a cooperation in the fields of electromagnetic sensors, modeling, simulation of electromagnetic fields and superconducting high-speed electronics. Professor Töpfer expects as a result of the cooperation with the IMMS – as the link between basic research and practical applications in industry – to generate attractive offers for industrial and research partners in the region with respect to the solving of current problems and thus thereby contribute to strengthening the technology ability of the region.

IMMS Kids

Greta Carlotta Langenhan,
born 16 October 2008

Luise Hübner,
born 14 February 2009

Samuel Karolewski,
born 19 October 2009

Carla Luise Engelhardt
born 27 July 2009

Dipl.-Medienwiss. Ines Lehrke, PR Manager,
ines.lehrke@imms.de

Research and Solutions for the Industry

Verdian

„The project VERDIAN is the hitherto peak in the long-standing, very close and fruitful collaboration in research and development with the IMMS. In the course of this project new technologies, hardware and software components have been developed for direct drive technology, which we have subsequently implemented in various TETRA products. A prime example hereby is the sensor integrated signal processing and connection to a real-time bus of the 3D-measurement-test-head MIR. This has been the basis that has made it possible to already develop more independent products from the R&D results during the course of the project. The cooperative collaboration with the IMMS is for us an important integral part of what we need to secure our leading market position.“

Olaf Mollenhauer, Managing Director
TETRA Gesellschaft für Sensorik, Robotik und Automation mbH

Scalable Multi-Coordinate Direct Drive System for Precision Manufacturing

Modern precision manufacturing technologies and precision measurement technique require highly dynamic multi axial positioning movements with positioning and path accuracies in the sub-micron range. These can for example be planar movements with respect to for example the laser precision machining of metal parts or the inspection of masks for chip manufacturing. However spatial trajectories for the manufacture of stents, surgical needles and instruments, or for 3D measurement technology are also becoming increasingly important. The movement areas currently range from 100 mm to 1,000 mm for each axial direction. For these types of precision manufacturing, direct drive systems are increasingly being used that move within a multi coordinate system.

Development Goals

VERDIAN „Networked Integrated magnetic direct drives“, is a collaborative research project that was initiated in order to meet the future demands placed on direct drive systems with respect to movement range and accuracy. Ten companies and two research institutes hereby conducted research and development work on new technologies and procedures that should allow not only highest accuracy in the sub-micron range by concomitant industrial robustness, but also realize other innovations in direct drive technique. These thereby include among others new functional structures of the drives, modern control and feedback strategies, real-time communication and modular design.

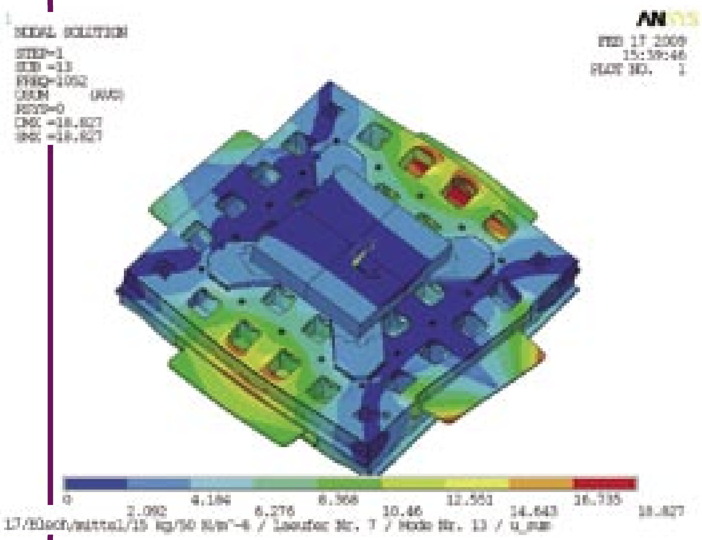


Figure 1: Deformation of the rotor assembly group by the excitation of the natural frequency

Within the framework of the project, the IMMS addressed the theme „Multi axial direct drive systems with modular network control". This entailed inter alia, the following research and development priorities:

- New machine concepts for modular designed multi axial electromagnetic drive systems with large movement ranges
- Distributed control of multi axial drives
- Real time networking of controllers and other components
- Modular hardware and software platform for universal control modules

Fundamental research was conducted on the basis of a linear and planar electrodynamic direct drive with movement ranges of up to 250 mm x 250 mm that was developed by the IMMS. This was meant to generate further insight, for example in to the various factors influencing the accuracy of these complex machines. The focus of the research was hereby on

- drive-, control-, feedback- and software components, including a modular and interchangeable design of all interfaces,
- designing the functional structure of complex drive systems in such a way that the movement ranges are scalable – while concomitantly implementing a sub-micron accuracy and
- to achieving a – in line with the module concept – optimized design of the multi-axial drive systems for the end application.

In the course of the research on numerous functional structures, different application scenarios, various drive principles and form variants of the machine were taken into account such as different manufacturing and assembly technologies as well as materials. The design of the multiple coordinate drive was carried out under constant verification of the properties of the assembly groups in the form of static, dynamic, thermal and modal analysis with the help of FEM (see figure 1). Thus, in the design process, deformation during acceleration processes or the excitation of resonant frequencies by the drives could for example already be prevented.

The result was the design of a multi-coordinate direct drive, which was realized as a demonstrator „MKDA" multi coordinate direct drive system (see figure 2).

Besides the complete newly designed mechanical hardware, physically and functionally distributed control and feedback strategies, the components of the control and feedback electronics as well as the displacement and angle measurement systems were developed.

Figure 2: MKDA multi coordinate direct drive

The communication among the modules is based on a flexible, real time capable network with EtherCAT®. This was based on already existing standards and was developed following a consistent scheme for the consortium. The machine control will be based on a modular control software, with an application specific configuration and the possibilities for parameter self-recognition, self-diagnosis and self-calibration. Other software components are for remote diagnostics and maintenance, as well as the sensor based Machine Health Monitoring.

The development of the various hardware and software components were conducted partly at the IMMS or in close cooperation in the project working groups, in which one or more partners were involved.

In the course of project realization, besides the work in the aforementioned main points of focus, further experimental setups were realized at the IMMS that serve to test key partial aspects. These thereby included among others, tests on bearings and guides, the thermal behavior of assembly groups and the electromagnetic compatibility (EMC), and vibration tests on machines to assess the installation conditions.

Results of the VERDIAN Project

A significant outcome of the research collaborative project was the realization of the modular designed and scalable demonstrator „MKDA" with a movement range of 400 mm x 400 mm and a path and positioning accuracy of 1 micron. With it, the concepts of distributed control and feedback of modular multi-axial systems with distributed intelligence can be verified. In addition, the demonstrator „MKDA" will serve as a basis for further research activities of the IMMS.

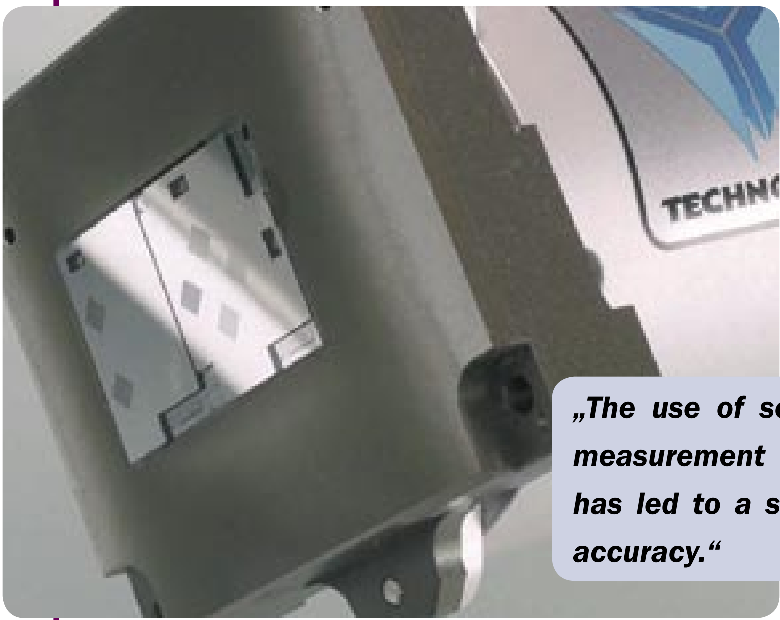
The hardware-in-the-loop simulation system that was designed in the project is used for the simulation of drives and controls by the further development of control algorithms and software. This makes it possible to completely already develop the necessary algorithms and the corresponding software before the actual hardware is made. It can also be used as an automated test system for real assembled controllers.

In addition, numerous hardware and software components for real time control systems based on EtherCAT® have been realized, such as Master and Slave modules as well as a 3-channel measurement system with integrated signal processing (see also article „Measuring Head with Integrated Signal Processing"). The sensor head is the first of the project results that was transferred together with the participating industrial partner – the TETRA GmbH – to product development stage. The same has been planned for the other project results, as is generally envisaged for all research projects of the IMMS.

The project VERDIAN was funded by the BMBF (project number 03WKY01A).

Dr. Frank Spiller, Project Manager, Mechatronics,
frank.spiller@imms.de

MEASURING HEAD WITH INTEGRATED SIGNAL PROCESSING



„The use of sensor proximity signal processing in the measurement systems of modern positioning systems has led to a significant improvement in resolution and accuracy.“

In medical and laboratory technology, materials research, surface analysis and other areas, high technology is needed to carry out precision machining (e.g. with laser cutting machines) and precision measurements (e.g. with coordinate measuring equipment) on the smallest scale.

An illustrative example of the use of these high-precision machine tools is the production of medical products such as of stents or medical needles. For these applications, it is necessary to work very accurately in the sub-micrometer range, in order to be able to "cut out" the given contours exactly the same way as specified. The use of sensor proximity signal processing in the measurement systems of modern positioning systems has led to a significant improvement in resolution and accuracy. Furthermore, this approach increases the modularity and maintainability of the measuring system, thus facilitating the integration into the overall system.

SETUP OF THE MEASURING HEAD

Taking into account the aforementioned aspects, within the framework of the growth core program initiative „VERDIAN" (Networked magnetic direct drives), in cooperation with the TETRA GmbH, a sensor head with integrated digital signal processing and connection to the EtherCAT® bus has been developed (see figure 1).

It allows the interpolation of the position signals of three optical sensors for detecting reflected light and is designed for use in high-precision planar direct drives that were developed at the IMMS. Three optical displacement sensors are integrated in the

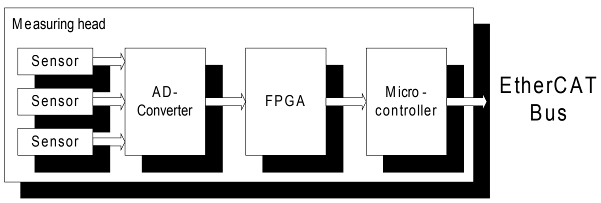


Figure 1: Block diagram of the measuring head

measuring head. Each of these sensors provides two 90° phase shifted sinusoidal analogue signals, which are sampled up to 50 MHz by an analog-digital (A/D) converter. Further processing of the digital sensor signals has been realized with a programmable hardware (FPGA). This is particularly suitable for fast processing of digital signals, is reprogrammable and cost effective.

The digitized sensor signals are read into the FPGA, through an interface to the A/D converter. The position calculation is performed in parallel with one interpolator per measurement channel. This includes an amplitude and offset correction of the sensor signals, the actual position calculation is done with the help of an iterative algorithm. The communication of the following microcontroller with the FPGA is conducted via a parallel interface. This includes the parameterization and reading of data, e.g. that of the current position. The microcontroller realizes the connection to the EtherCAT® bus, which ensures the integration into an overall system.

It is also possible to use the integrated electronics in the measuring head as separate assembly groups. Standard encoders can then be very simply integrated in EtherCAT®-based networks. The design of the digital signal processing in the FPGA was carried out model based with Matlab/Simulink®. This allows for a graphical design, simulation and verification of the algorithms at the system level, thus reducing development time. The developed signal processing algorithms were then ported on the target platform with the help of a hardware description language.

Transfer into Industrial Solutions

The solution presented entails a self-contained module for position measurement of planar direct drives (see figure 2).

Figure 2: Picture of the measuring head

The direct and high-performance signal processing directly in the measuring head as well as the implementation of an EtherCAT® interface that enables a smooth real-time transmission of signals to the respective drive controller, eliminates the need for the transmission of analog sensor signals for local processing to a remote PC.

As a pure EtherCAT® interface with signal conditioning and interpolation, the presented system enables the integration of three fully synchronous encoder channels in an EtherCAT®-based control system with the highest resolution and processing speed.

The incorporation of this innovative measurement system into the direct drives of TETRA GmbH, made it possible to significantly improve the process quality for the customer. The measuring head is therefore a flexible building block for all the future requirements of automation technology and significantly boosts the declared goal of this sector, which is to implement standardized EtherCAT® cabling for such production processes.

Dipl.-Inf. Marco Götze, Scientific Staff Member, System Design, marco.goetze@imms.de

Laser Dicing Technology for Thin Semiconductor Wafers

Planar Precision Drive for 12 inch Wafer Dicing

„As a result of competent and creative collaboration, at the end of 2009, the company ALSI was able to take the first prototype of its new 12 inch laser dicing platform into operation. The achieved extreme precision, reproducibility and productivity of the laser dicing technology are at the forefront of international excellence. This is significantly boosted by the planar drive system developed by the IMMS. The close cooperation with the IMMS leads to innovative developments, which is a basis that we can count on to expand our position as a leading technology provider.“

Peter Chall, Director and CEO, A.L.S.I.
Advanced Laser Separation International

The classical mechanical sawing of semiconductor wafers to separate chips is increasingly being displaced by procedures, which bring about a separation by means of a focused laser beam. Here on the other hand, there is a competition among processes, which bring about a separation by means of material removal in the form of several successive spots (Multi Beam Laser Ablation) or in the form of a water jet guided laser beam. In addition, systems are available on the market, which bring about a separation by inducing a mechanical stress path and microstructural changes within the wafer and subsequent expansion (stealth dicing). Besides, systems are also available on the market that work with thermally induced stress on the upper stratum of the wafer by means of laser heating with an immediate subsequent cooling (Thermal Laser Separation).

The individual processes offer different advantages and disadvantages. The one thing that all however have in common is that the envisaged gap between the chips with respect to the separation can be significantly reduced vis-à-vis the classic sawing. Typical separation columns are smaller than 20 μm. This is particularly of great importance for small chips, such as LEDs, transistors, diodes, etc. Whereas a saw can only cut in one direction, the laser process allows a separation in both directions of movement. Besides, the possible processing speed – especially for brittle and thin wafers – of up to 500 mm/s is significantly higher than the conventionally attainable values. Due to the significant benefits that the aforementioned processes have in common, Laser Dicing is regarded as the technology of the future.

The potentially high processing speed by the laser separation can only be effectively used when the wafer is moved under the beam with higher precision and dynamics. Together with the company ALSI N.V. and the Institute Centre for Concepts in Mechatronics B.V. (CCM) a laser dicing system was developed at the IMMS, which enables the mounting of the process for thin wafers on a die attach film. The IMMS was within the framework of the project in particular responsible for the planar drive system of the wafer table and its control.

Planar Drive System

The precision drive system consists of a two-dimensional planar magnetic direct drive. The motor glides on air bearings over a high-level steel/granite sandwich, whereby friction independence and high durability is achieved. A special cooling system of the drive coils ensures precise temperature control of the assembly groups and maintenance of flatness. Also through an additional integrated magnetically acting twist lock, a completely contact less and frictionless guidance of the wafer table is as such ensured.

The drive permits an acceleration of up to 10 m/s^2, a driving speed of 500 mm/s over a driving range of 380 x 380 mm^2. Thereby even by maximum speed a regulated path deviation of less than 1 μm is achieved that makes very narrow „cutting lines“ between the individual dies possible.

Figure 1: Test structure of the planar system with Active Mount System

Active Mount System

The high acceleration of the wafer table that is needed for the fast cutting process, leads in precision machinery to unacceptable distortion and vibration of the machine frame and the metrology frame and has as such, an adverse influence on the achievable machine accuracy. This effect is counteracted in the developed machine by an „Active Mount System". Linear actuators generate to the wafer-table movements, timely synchronized opposing forces in the machine frame, in order to minimize the inherent vibration. Besides, these actuators are used for the elimination of the effect of vibrations from external interference sources on the system.

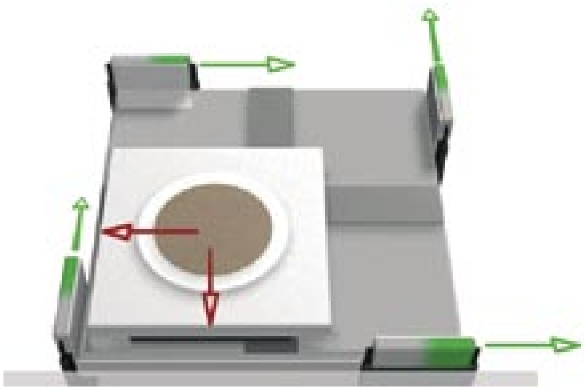


Figure 2: Mode of action of the Active Mount System

Optical 3D Measurement System

An optical incremental grid plate that is metrological stable is directly coupled to the wafers that are to be processed from underneath them and serves as a scale to measure the rotor position in the coordinates x, y and r_z. The area of this scale is scanned by a 3D measuring head with EtherCAT® encoder interface. The extrapolated sensor signal positions are made available via the serial interface for a variety of control processes in the EtherCAT® network

Innovative Solutions for the Economy

The technology of the presented wafer dicing system enables, when compared to conventional mechanical sawing, a productivity improvement of up to 500 percent. This is depending on the technological application area and is achievable not least because of the integrated planar drive technology. This also allows for savings from wafer surfaces through much narrower cutting paths. Moreover, it is for specific technology areas such as the processing of RF chips due to the brittleness of the wafer material used or by the very small thickness of the wafer by the currently available technology for the separation of the dies.

Dr.-Ing. Christoph Schäffel, Head of Mechatronics,
christoph.schaeffel@imms.de

Personalized Miniaturized Dosimeter

„Thanks to the capabilities of the IMMS staff in complementing our skills, we have been able within an increasingly uncomplicated and enjoyable collaboration, to develop our concept of a personalized miniaturized dosimeter up to a stage close to serial production and maturity in less than three years. The result is a globally unrivalled dosimeter system with measurements of individual noise pollution in the ear canal, which means directly on the site of the cause. I am not aware of any other institution, with whom we have been able to achieve such flexible complex micro-technical systems ‘under one roof‘.“

Univ.-Prof. M.Sc. (Eng.). MD (habil.) Hartmut Witte, Specialist in Anatomy, Department Biomechatronics, Institute for Microsystems Technology, Mechatronics and Mechanics in the Faculty of Mechanical Engineering, Ilmenau University of Technology (TU Ilmenau)

Mobile Audio Dosimeter for Noise Prevention

Exposures to noise pollutions are an often underestimated heavy strain at work and in leisure time. Thus, as shown in figure 1, the diagnosed cases of occupationally related noise-induced hearing impairment are consistently high and deserve as the second most occupational disease – since preventable – special attention. Especially in the professional environment, it is important to reliably and reproducibly measure and record occurring noise pollution in order to effectively protect the worker and to meet the legally specified limits.

Existing methods for detecting the noise pollution at the workplace often do not consider the respective working conditions of the individual employees, such as directionally dependent sound sources that may lead to varying degrees of exposure of the right and left ear. Also, a verification of a contingently used hearing protection is not possible. To circumvent such problems occurring and to allow

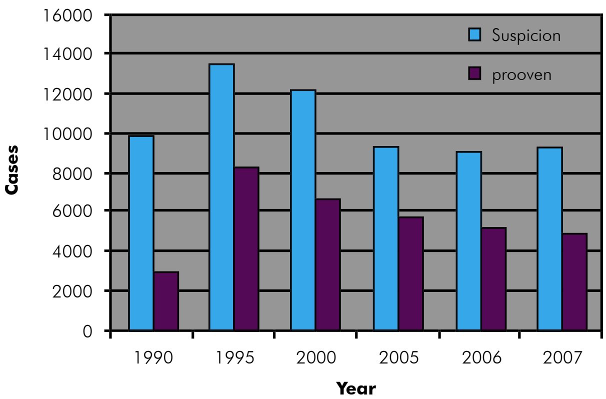


Figure 1: Occupational noise-induced hearing impairment in Germany (Source: HVBG)

an individual, mobile, physiologically correct sound immission measurement in the ear a personalized miniaturized (noise) dosimeter – short PMD – was developed at the IMMS in collaboration with the faculty of Biomechatronics of the TU Ilmenau, commissioned by the German professional association for statutory accident insurance and prevention in the foodstuffs industry and the catering trade (BGN).

Development and Implementation of a PMD

The following key requirements were, inter alia, placed on the development of the designated device:

- Binaural (both sides) sound recording
- Physiologically correct immission measurement inside and outside the ear
- Wide-band and high-resolution sound recording
- Mobility

Furthermore, the PMD should be able to measure and record Transitory Evoked Otoacoustic Emissions (TOAE). TOAEs are retrograde sound emissions triggered by the hair cells of the inner ear through stimulation with the help of a broadband acoustic pulse. These signals can be used for the diagnosis of the condition of the hair cells as well as for predictions on the general hearing ability. Thus TOAE measurements are currently e.g. deployed in the screenings of the hearing faculty of the newborn, in order to allow an early detection of possible hearing impairment. Conducted or ongoing research at the TU Ilmenau focuses on the possibility – through the change of TOAE-signals over time – to make predictions on the individual noise stress of the exposed persons. This is a hitherto unprecedented approach in the diagnosis of occupational noise exposure [1], [2]. Based on the compiled requirements for the device, it was possible to derive an appropriate hardware setup for the PMD, at the Institute.

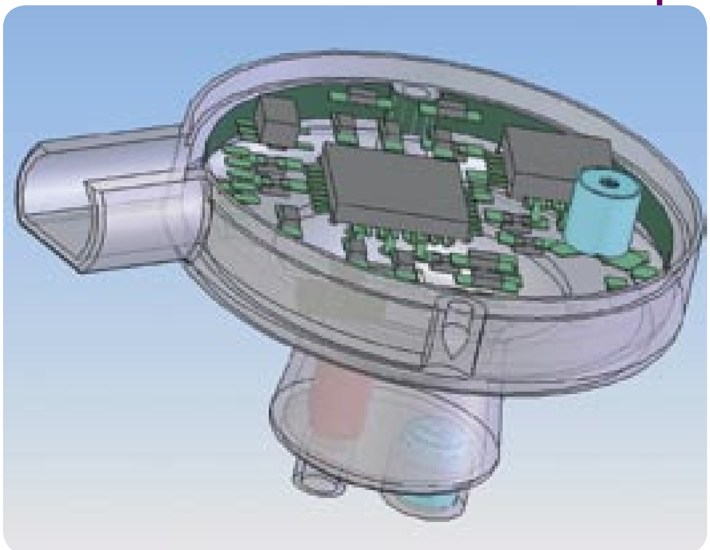


Figure 2: A Otoacoustic probe

This is divided into two groups of devices. On the one hand a mobile front-end (see figure 3) for processing, displaying and recording the resulting data, on the other hand two probe assembly groups (see figure 2) for the audio recording each with two microphones (in the interior and exterior of the ear) and a speaker for audio playback.

To minimize interference to the analog audio signals, the digital-analog conversion using an audio codec is conducted close to the signal source. The form factor of modern assembly parts allows their direct use in the otoacoustic probe.

For the front-end assembly group a FPGA for data preprocessing and a microcontroller for all other tasks are used. Despite of the mobility of the device, its operability has still to be ensured. To this end, a display and a thumbwheel input controller are provided. Similarly, for reasons of mobility, the power supply of all components is provided by lithium ion accumulators. For the data recording, SDHC memory cards with a capacity of up to 32 GB are applied with the help of an appropriate interface.

Figure 3: PMD front-end

For a complex device such as the PMD, the use of appropriate software components is a prerequisite. The used software stack therefore essentially consists of a boot loader, a universal operating system, a daemon component for signal processing and a graphical user interface. By the selection of the components caution is taken to ensure that only open-source-software is used. As a boot loader, the U-Boot – de facto standard for embedded systems – is used. It is responsible for the basic initialization of the PMD hardware and the subsequent loading of the operating system kernel – here, the Linux kernel in version 2.6.26. The access to the hardware components is conducted respectively through appropriately designed device drivers. For the implementation of the user interface the QT-Embedded-toolkit was used, which allows a comfortable tool-supported design of the graphical controls.

Basic functions of the PMD are the collection of activity based noise dose according to the German noise and vibration-work safety regulation (LärmVibrationsArbSchV [3]). In addition, the effectiveness of an ear protector can thus be verified. The measurement of the noise dose is conducted as follows: The sound recording is performed simultaneously by the four microphones placed in the probes. The thus obtained signal is transmitted to the front-end and either filtered (A, C) or not filtered at all from the FPGA depending on the chosen setting. With the help of these standardized filter curves, the frequency response of the human auditory system is simulated. This is followed by further processing of the signal in the application processor that among other things performs the calculation of the energy equivalent of the averaging level according to DIN-EN-61672-1 [4]:

$$L_{eqT} = 20lg\frac{\sqrt{\frac{1}{T}\int_{t_1}^{t_2} p_A^2 dt}}{p_0}$$

The time weighting (averaging time T) in the calculation, is adjustable in dialog in accordance with the requirements of European standard (Impulse, Fast, Slow). Computed in addition, are the noise dose and the maximum level. All the calculated values as well as those optionally selectable, also the audio raw data are stored on a SD memory card.

Fields of Application

All requirements placed on the device (see figure 3) could be successfully implemented. The mobile runtime of more than ten hours has superseded the required eight hours. Similarly, in terms of signal processing aspects, the challenging recording and analysis of TOAE-signals is possible without a problem. The finished functional models will be evaluated by the BGN on selected workers with reference to noise stress measurements such as in production halls.

The flexible high-speed digital interfaces, the long mobile runtime and universal programmability of the PMD also opens up the doors to many other application fields in addition to the audio dosimetry e.g. as a recording device for long-term ECG with simultaneous signal processing or as universal data logger.

Dipl.-Inf. Thomas Elste, Scientific Staff Member, System Design, thomas.elste@imms.de

A Wireless, Energy-Efficient Sensor Network for the Building Automation Sector

„In order to enhance comfort and ease of use, individual requirements placed on building control systems by the users are more often the center of focus.“

In our everyday life, building automation is becoming increasingly important in order to enhance comfort and ease of use. Thereby the individual requirements placed on building control systems by the users are more often the center of focus. In order to optimize various aspects of building control systems such as room temperature, incidence of light but also humidity, specific sensors detect the various input data, in order to pass them on for evaluation and as such to the control system.

By a fixed wiring, the hereby used sensors can only collect the measurement data at certain fixed points. This makes it difficult to respond to the individual requirements and needs of individual building users and to take them sufficiently into account in the course of the use. Thus a change of a user in the building often leads to other requirements for the building control system. In order to master this situation and to be able to flexibly adapt the control system to new circumstances, the input data should be recorded in the immediate vicinity of the respective user. Only the wireless transmission of sensor values enables this flexible positioning of the sensors. A technical challenge is thereby the necessary energy efficiency at the sensor nodes.

Within the framework of the collaborative project „Customer Bautronic System“ (CBS) [5] IMMS developed specifically for this purpose the wireless sensor network „BASe-Net“.

The heart piece of the sensor network is ultimately the sensor module, whose development is a crucial step in the whole hitherto done research and development work of the IMMS.

System Architecture of the Sensor Module

The system architecture is based on the open-source-operating system TinyOS that is set on the IEEE 802.15.4 [6] standard. The architecture of the hardware abstraction simplifies significantly the porting to a specific hardware just as the control of the system components through the application software (see figure 1). In addition, the integrated power management of the operating system kernel makes a very energy-efficient operation of the sensor module possible.

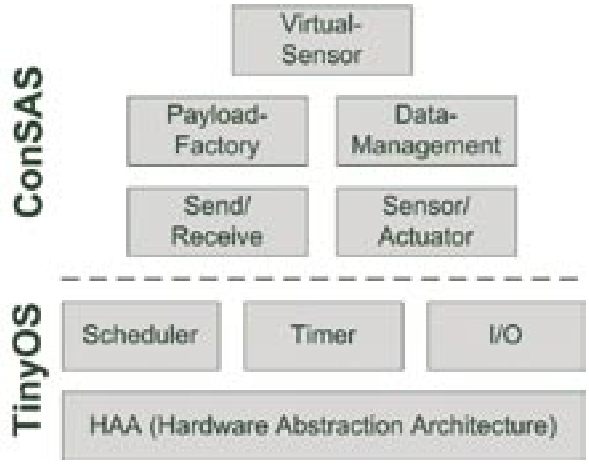


Figure 1: System architecture

At the application level the IMMS has created the software ConSAS;

- that enables the identification of different modules
- makes the configuration of the system, the actuators and sensors as well as the parameters of the Media Access Layer (MAC) and routing significantly easier,
- and is able on the basis of multiple sensor values to create a new virtual sensor. This makes it possible to generate from the sensor network, a particular sensor value and as such to generate an own value for places where no sensor can be placed.

In summary – resulting from the combination of TinyOS, the application software ConSAS developed by the IMMS and the gateway application framework (GAF) [7] – are the following benefits:

- Easy exchange of the target platform
- Integration and identification of sensor nodes from different manufacturers and different sensors systems
- Compatibility of the transceiver circuits at the MAC-level
- Automated, needs-oriented power management
- Transmission of different data types
- Pre-computation within the network

Due to the modular design of the sensor nodes, the application software ConSAS and the GAF, the sensor network can easily be adapted to other tasks.This can be done through integration of foreign sensor systems and has already been demonstrated with the integration of energy consumption meters [8] of the company „Energy Optimizer Limited“. Hereby, there is a „translation“ of the communication protocol of the sensor to the communication protocol of the BASe-Net.

The measured data of the sensor modules are routed to the BASe-terminal (software), which operates on a standard PC or laptop. The BASe-terminal takes over the data, provides the interfaces for their export and makes the administration of the wireless sensor network possible. Figure 3 shows the front end of this software.

Hardware Design of the Sensor Module

The kernel of the sensor node consists of a microcontroller-transceiver-combination ZigBit [9]. Entailed in the ZigBit modules are a:

- Low-Power Microcontroller ATmega1281
- 2.4 GHz IEEE 802.15.4 transceiver AT86RF230

In addition to a microcontroller, a 32 kHz low-power quartz is present on the module. Thus, the internal RC oscillator can be calibrated, or a Real Time Clock can be realized. A small construction space with good RF characteristics is achieved through the use of chip antennas. The radio module is enhanced with the sensors systems (light, humidity, temperature, possibly CO_2), as well as with push buttons and with a flash assembly module as data and configuration memory (see figure 2). Based on this hardware design, sensor nodes can be implemented with different features and different sizes.

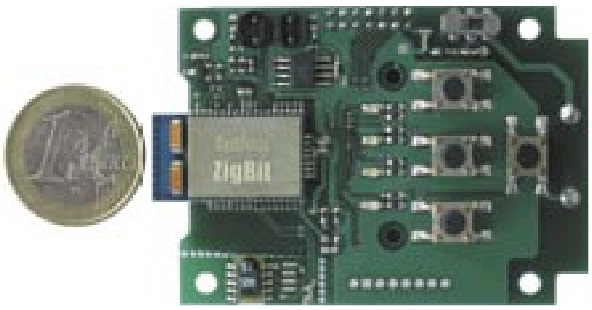


Figure 2: Size comparison between sensor module and 1€

Optimized Access to the Transmission Medium

The transceiver circuit and the microcontroller, followed by the sensors, are the largest energy consumers. Through a clever sampling of the radio channel, a synchronization of the participants or the use of TDMA – a multiplex procedure for signaling and messaging – an energy-efficient operation can be attained. All three methods are used to reduce the time in the transmit (Tx) and reception mode (Rx) to a minimum and nevertheless still route the messages of other sensor nodes and continue to meet QoS or possibly real-time requirements.

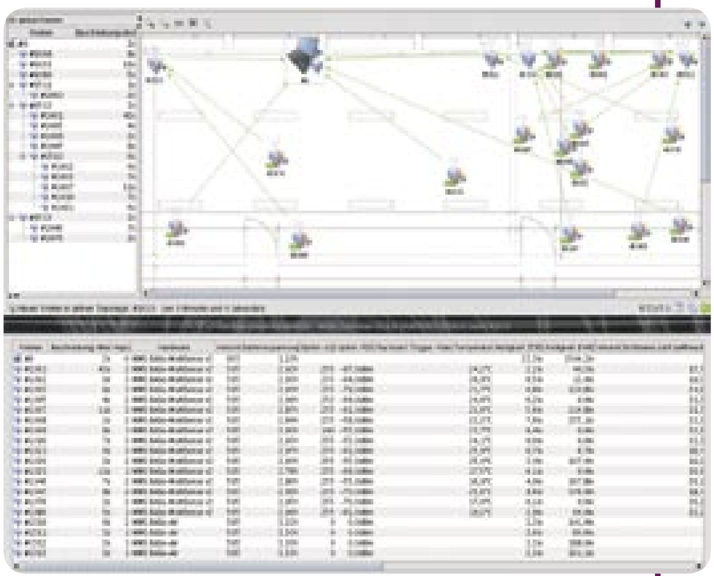


Figure 3: Cluster-Tree Network

The application software ConSAS developed at the IMMS, offers in contrast to the operation with B-MAC, the opportunity to build a cluster-tree network (see figure 3). Sensors, whose high energy consumption require a permanent power supply (e.g. CO_2 sensors), thereby assume the role of the Cluster Head. It routes the data of its sub-nodes (according to the sensor nodes assigned to it in the network structure) and other cluster heads to a base station.

Thus the measurement data of the sub-nodes readings can be very energy efficiently compiled and relayed to their cluster head.

On the basis of the presented software and hardware, the possible period of operation was estimated [10], which, depending on the power source and the actual task can be specified to be between five to ten years.

Conclusion

The wireless sensor network, developed specifically for building automation by IMMS allows at present the compilation of the illumination strength, temperature, humidity, CO_2 or CO concentrations in the air and the energy consumption of electrical appliances. The collection of data in very close proximity of the user makes it possible to address the real needs of the user and thus a new level of building control.

Due to the modular design of the sensor network, it can easily be adapted to various tasks, such as energy consumption measurement, air flow measurement or concentration of pollutants in the air. A BASe-Net of the IMMS, which consists of several multi-sensors and energy consumption meters, is currently being deployed in the Fraunhofer Application Center for Systems Technology (AST) in Ilmenau, for the decentralized energy consumption compilation of electric terminal devices.

The work was conducted within the collaborative project CBS, funded by the BMBF, project number 03WKBD3C.

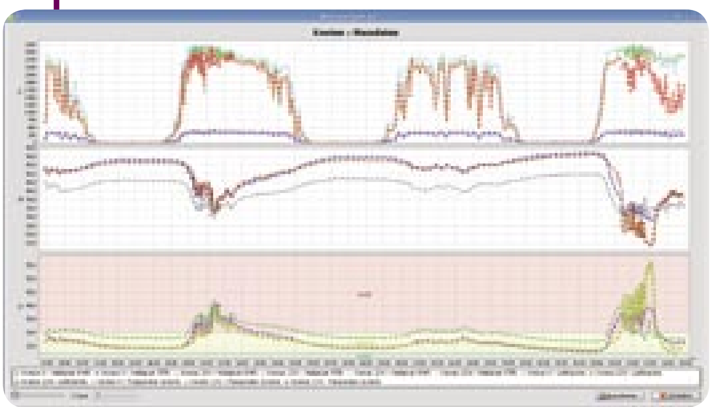


Figure 4: Measured room climate conditions (air, temperature, humidity, light) collected by multiple sensors

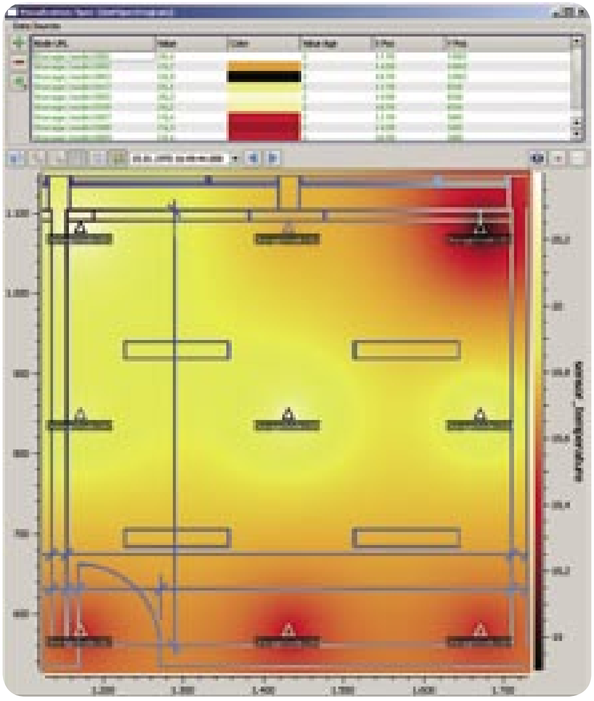
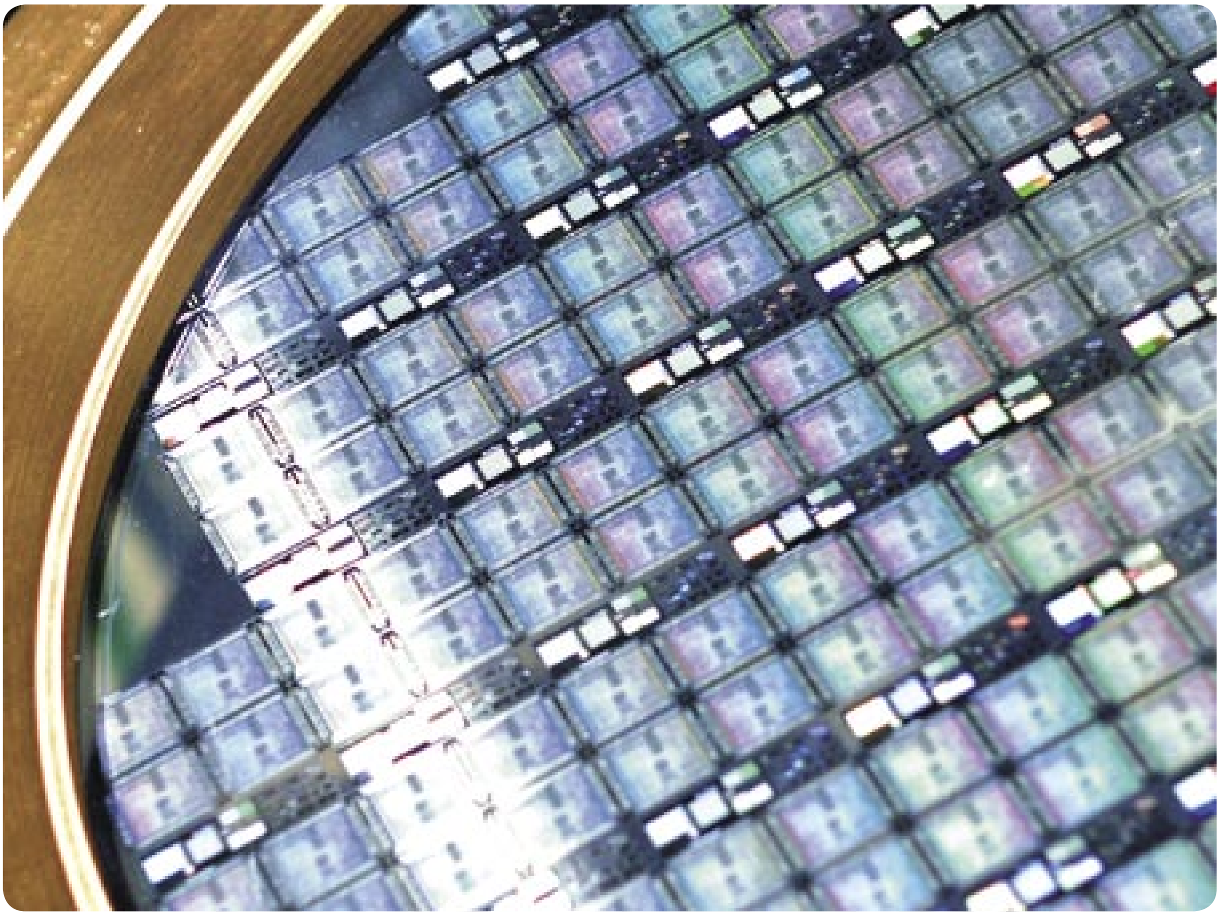


Figure 5: Temperature distribution within a room

Dr.-Ing. Axl Schreiber, Scientific Staff Member, System Design, axl.schreiber@imms.de

Wafer Level Testing of MEMS

Development of Test Procedures and Systems



„The test of the sensor on the wafer level can already lead to the detection of a faulty sensor and therefore to the reduction of costs.“

MEMS (Micro-Electro-Mechanical Systems) has experienced in recent years a fast-paced growth due to the establishment of new application fields. This can be significantly attributed, other than to increased functionality, also to the lower costs per sensor chip. A significant share of the costs in the processing of a sensor is attributed to the test due to the thereby high level of reliability required. The test of the sensor on the wafer level can already lead to a reduction of the share of the costs – through the detection of a faulty sensor, the subsequent packaging and assembly steps are omitted.

The area MEMS at the IMMS is primarily concerned with the testing of MEMS at the wafer level. This entails among others, the development of optical measurement processes to identify geometric and material parameters of the MEMS.

The parameters of interest are identified by an inverse optimization procedure that is based on the one hand on vibrometric measurements of natural frequencies and on the other on a finite element modal analysis.

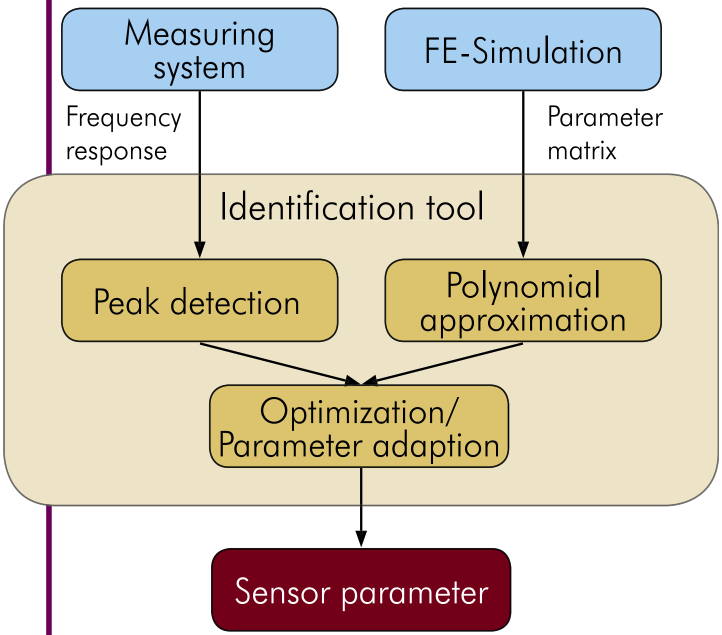


Figure 1: Structure of the parameter identification

A further main focus is the development of MEMS test systems. The IMMS is in this respect e.g. partner in the EU-funded project SMARTIEHS (Smart Inspection System for High Speed and Multifunctional Testing of MEMS and MOEMS, term 2008-2011), in which the focus is on a parallelization of the optical measurements. Compared to conventional serial measurements, the measurement time can thereby be shortened up to 1/100, which in turn means a significant cost reduction. The IMMS is within the project responsible for the mechanical and control engineering aspects of the overall concept of the measurement system as well as their implementation.

Parameter Identification using Dynamic Measurements

The identification of geometric and material parameters of MEMS using dynamic measurements is based on the measurement of out-of-plane natural frequencies, such as typically exhibited by membrane or beam structures. This allows, in practice, an identification of up to three parameters, provided that the parameters of interest have a dependence on the natural frequencies. Examples of identified parameters are the membrane thicknesses of rectangular test structures between 10 to 30 μm, which were determined with an accuracy of 100 nm as well as material stresses in thin membranes with an accuracy of 1 MPa.

Figure 1 shows the structure of the measurement process. The measurement system that consists of a semi-automated SÜSS probe-station, an electrostatic excitation unit and the Micro System Analyzer MSA400 from Polytec, delivers a frequency response. The parameter matrix, which is necessary to identify the frequency parameter, is calculated using finite element simulations. The extraction of the parameter of interest is conducted with the help of measurement and simulation data as input parameters in the identification tool, which was developed at the IMMS. Sub modules of this tool are other than the actual optimization, the peak detection as well as the polynomial approximation. Within the process the peak detection extracts the frequency peaks from the measured frequency response, and the discrete data of the parameter matrix are approximated by a polynomial function.

The parameter identification can be used both in the characterization of sensors in the development process as well as by a wafer test in the production. Whereas by the characterization a defined fine-sectioned grid of vibrometer measurement points is required for the determination of the mode shapes (see figure 2), a minimization of the number of the measurement points instead takes place during the production test with respect to the measurement time. The optical measurement system, the prober and the identification software are combined on the software side, in order to realize the measurement of a complete wafer.

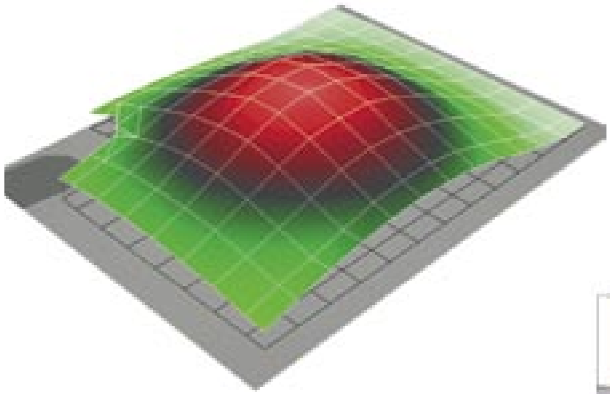


Figure 2: Measured mode shape (1. natural frequency)

Parallel Testing of MEMS – EU Project SMARTIEHS

The above-presented procedure just like other optical test procedures (e.g. measurement of deflection) works sequentially, whereby larger measurement times may be caused in particular by the test of a complete wafer with small dies. The parallel measurement of several dies – that is pursued in the concept for the to be developed inspection system within the framework of SMARTIEHS – allows on the other hand, a significant reduction in measurement time. The core of the system is a micro-optical processed interferometer-matrix, whereby 25 dies can be measured in parallel by the laboratory model that is currently in development. The analysis of the interferometer signal is hereby conducted with the help of a 5 x 5 matrix of smart-pixel cameras. The concept allows further scaling of the matrix, 8-inch wafer can for example be high efficiency tested with the help of a 10 x 10 interferometer matrix.

The project SMARTIEHS addresses development tasks from a broad range of research areas. Other than optical and technological problems at hand that are dealt with by the project partners, these are among others the constructive and control engineering tasks (e.g. the controlling of the overall system). Furthermore, software and hardware to process the camera signals will be developed and on the software side the commercial prober will be integrated in the system at the IMMS.

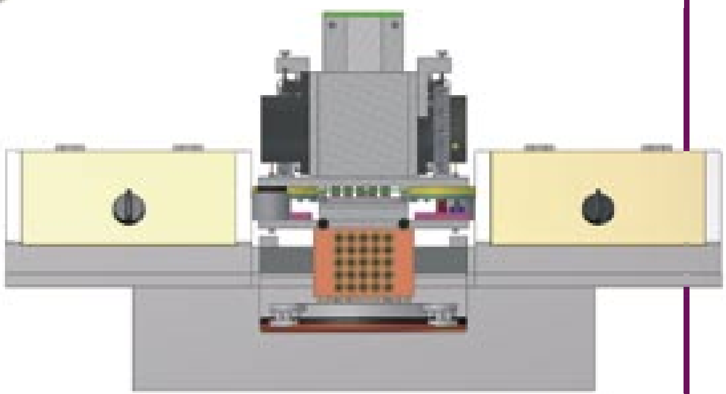


Figure 3: Inspection system with prober

The inspection system in figure 3 has two different interferometer matrices, which are in each case realized in a wafer composite. A laser interferometer realized as a Twyman-Green configuration allows the measurement of dynamic parameters such as natural frequencies and mode shapes, while a low-coherence interferometer based on a Mirau-configuration allows the measurement of profiles or deformations. The scanning of the surface in the z-direction hereby requires a high-precision drive system that is being developed under the framework of the project.

The inspection system is designed for use in the production and is accordingly integrated into a commercially available probe-station (company SÜSS, PA200). The positioning of the wafer as well as the rough positioning of the measuring system to the wafer via scope adapter is conducted through the probe-station. The inspection system has its own

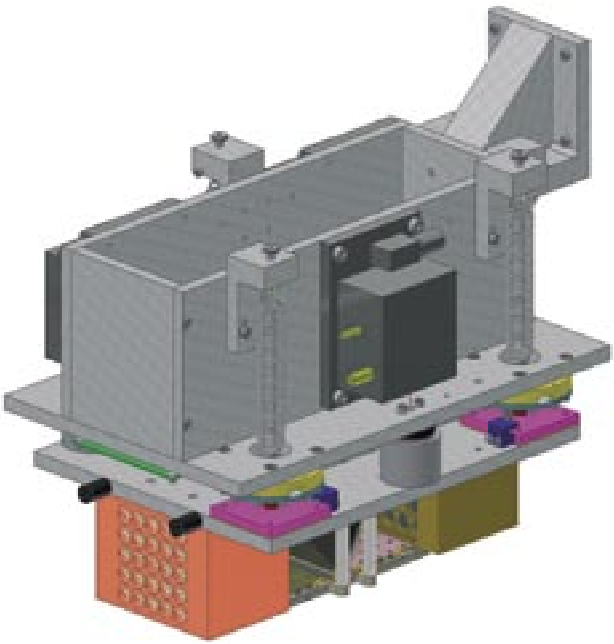


Figure 4: Schematically illustrated test setup of the inspection system with z-drive and optical components

high-precision z-drive consisting of three drive axes, for the parallel alignment of the interferometer matrix to the MEMS-wafer as well as the scanning mode. Three laser interferometers provide the position signals in order to attain a positioning accuracy of 10 nm in the z-direction.

Outlook

The main focus of the work in the next year will be centered on the installation, assembling and validation of the SMARTIEHS inspection system on the basis of test wafers, such as microphones and pressure sensors. Moreover, it is the envisaged goal, to evaluate further sensor types such as RF-MEMS for the presented method of parameter identification. An application of the method for the determination of material parameters such as material stress and elastic modulus of thin layers of materials science is also being considered.

The project was funded by EU/FP7-ICT-2007-2, project ID 223935.

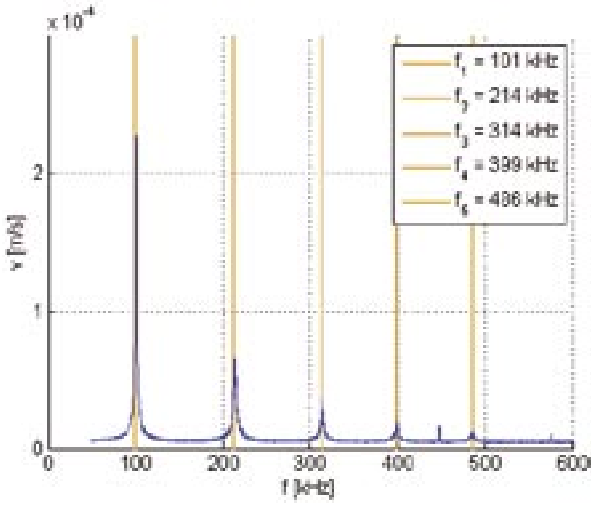
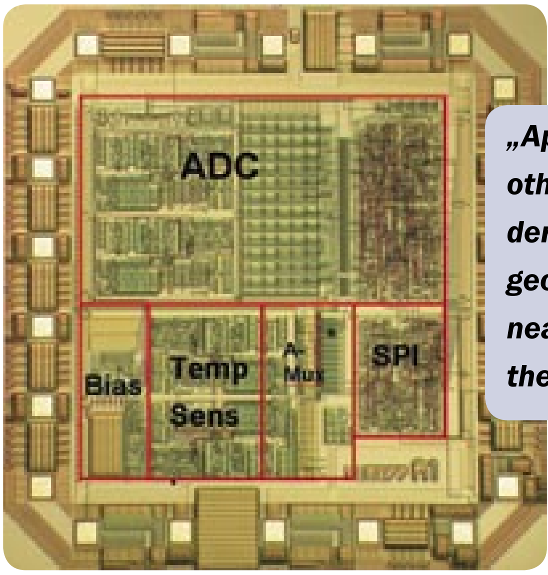


Figure 5: Measured FRF of relative pressure sensor

Dipl.-Ing. Steffen Michael, Project Manager
Simulation and Test MEMS, Mechatronics
steffen.michael@imms.de

Analog-Digital Converter for High Temperature Range

Design and Measurement of a 12-bit A/D Converter for Temperatures from -55 °C to 200 °C



„Applications for these converters include, among others, sensor applications that must operate under extreme temperatures like sensor systems for geological deep drilling systems, for the engine near applications in automotive engineering or in the field of aviation and space industries.“

Figure 2: Chip photograph of the A/D converter with SPI

The design of complex mixed-signal sensor systems often requires a conversion of analog sensor signals into corresponding digital values, which can then be used by a digital signal processing. To this end, analog-digital (A/D) converters with a high resolution of the analog value are required. For use in low ambient temperatures, there are many different types of converters up to those with very high resolutions and extremely high conversion rates. Above the operating temperatures of 150 °C, the choice is however much lower. For temperatures that exceed 200 °C, there is only one European commercial provider, who offers the A/D converter up to a 10 bit resolution. For this reason, it was of interest, to develop a high-resolution A/D converter with an extended temperature range from -55 to 200 °C. Applications for these converters are, for example sensor systems for geological deep drilling systems (analysis of temperature sensors, pressure sensors, etc.), for the engine near applications in automotive engineering or in the field of aviation and space industries.

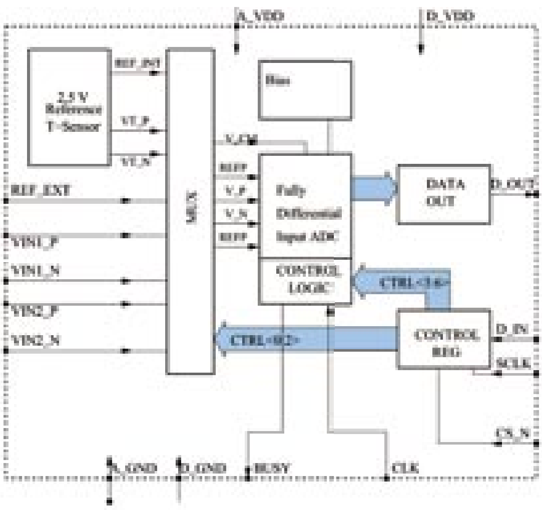


Figure 1: Block diagram of the A/D converter with SPI

Implementation and Progress of Work

Figure 1 shows the block diagram of the developed high temperature A/D converter ICs. The circuit has two fully differential inputs that can be connected to the A/D converter via a multiplexer.

There is also an internal temperature signal, which can be processed by the converter. The cyclic A/D converter converts each respective differential, analog input signal into a digital word which is written in a register. This register can be read by a serial parallel interface (SPI) and is thus available to the user of the circuit. The A/D converter can itself also be configured by the interface (SPI). It is possible, for example, to switch the resolution of the converter between 12 bit and 16 bit, to determine the offsets, or to switch to the temperature measurement mode. The circuit can thus also be used as a simple temperature measurement system. As a converter type a Nyquist-A/D-converter with one of cyclic RSD-architecture (redundant signed digit) was realized.

Figure 2 shows the die-photograph of the circuit realized in a 1-μm SOI CMOS technology. The chip area including bond pads is 5 mm^2. The individual sub-blocks described above are additionally identified in the figure. The circuit was put into operation and tested under different temperatures. Thereby tests on assembled packaged devices and dice on a wafer were carried out. Figure 3 shows the integral nonlinearity of the circuit as an example at 30 °C in normal mode. The resolution of the A/D converter was set to 16 bits. Figure 4 shows the same graph at a temperature of 200 °C. To determine the data for each set analog voltage value ten digital values were recorded and then used to calculate the mean value of the digital word. As one can discern from the two images, this is a converter with an effective resolution of 11.8 bits. The conversion rate is thereby 10 kSamples per second. By increasing the number of digital values to be averaged a resolution of 12 bits can be achieved, as subsequent measurements at lower temperatures have shown. The verification of the functioning at -55 °C has been shown successfully on a simulation level. The verification via measurement will follow as soon as the necessary testing and measurement equipment is available. The circuit functions also at even higher temperatures up to about 230 °C. At these temperatures the accuracy of the conversion decreases to an effective resolution of 10 bits however.

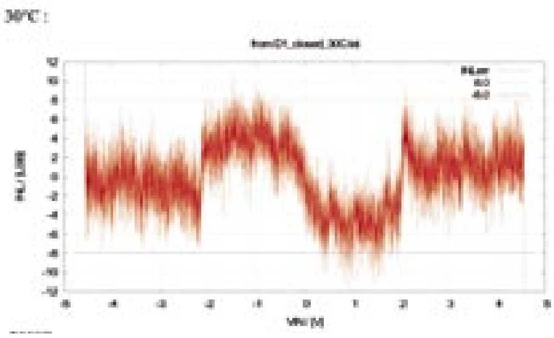


Figure 3: Measurement results for the integral nonlinearity (INL) at a resolution of 16 bits at 30 °C

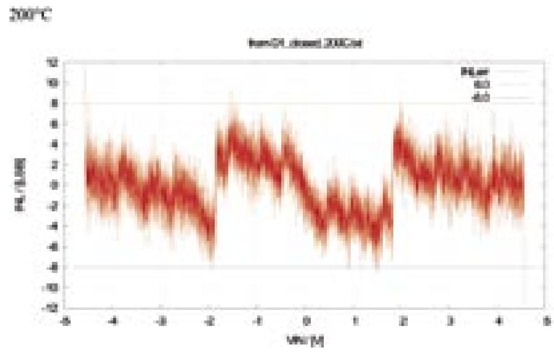


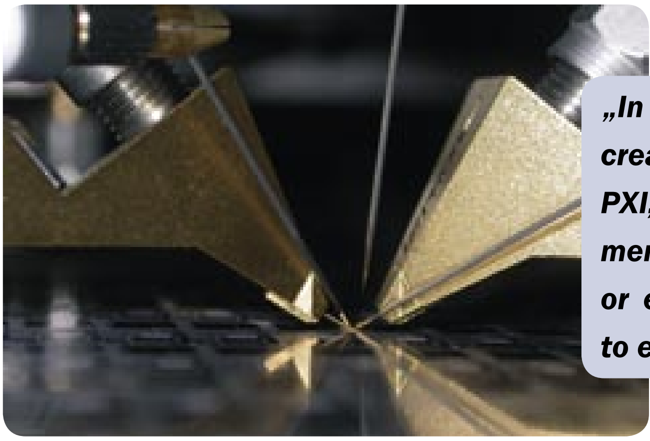
Figure 4: Measurement results for the integral nonlinearity (INL) at a resolution of 16 bits at 200 °C

With this converter two fully differential analog signals can be evaluated. The high temperature A/D converter presented here is available as a IP-block to the customers of the IMMS.

The work results presented here were developed under the project VERDIAN (BMBF, project number 03WKY01J).

Dr.-Ing. Dirk Nuernbergk, Project Manager SOI Design, Microelectronic Circuit Design, dirk.nuernbergk@imms.de
Dipl.-Ing. Reinhard Kindt, Scientific Staff Member, Microelectronic Circuit Design, reinhard.kindt@imms.de

Characterization with Modular PXI Test Systems



„In the future, the focus will be on the increased use of modular test systems based on PXI, in order to be able to adapt the measurement possibilities of software enhancements or external measurement devices optimally to each individual measurement."

Advances in modern computing technology make it possible to attain reliable simulation results of components and complex integrated circuits. It is nevertheless crucial that the parameter extraction and verification of the models are backed by radio frequency (RF) measurements up into the GHz range.

Conventional single devices have hitherto been used as measuring devices. In the future, the focus will however be on the increased use of modular test systems based on PXI, in order to be able to adapt the measurement possibilities of software enhancements or external measurement devices optimally to each individual measurement. In collaboration with the X-FAB Semiconductor Foundries AG in Erfurt, at the IMMS different setups were conducted to comprehensively characterize a series of RF cells with RF-IPs. The aim was to create sets of parameters and data sheets that allow the user to achieve an efficient circuit design.

Approach

The RF measurements can in general be conducted on the evaluation boards on the circuit boards or directly on the wafer utilizing a wafer prober. The connection is made over RF-impedance controlled needles (ACP probes), over a probe card or a test fixture. The use of Labview measurement programs on modular PXI test systems allows a high flexibility in the measurement, analysis and visualization of results.

The analysis of the measurement data forms the basis of the quality management that makes it possible to carry out a targeted error analysis. Furthermore, they are essential for an increase in the reliability of simulation results and for the provision of essential parameters for the redesign of the circuits.

In order to develop a complex RF transceiver, each individual internal circuit block has to be evaluated and characterized. Each RF cell and each technology has hereby its specific requirements and also the planned application requires different measurement tasks.

More generally, a variety of circuit blocks and IPs should be considered:

- Band gaps
- Bias Cells
- Operational Amplifiers
- Oscillators
- ADCs/DACs
- Voltage Regulator
- RF cells

The assembly blocks provided by the X-FAB, in various technologies and their detailed data provide a good starting point for the design of a customized solution, not only in the RF range.

Measurement of RF Cells

A radio transceiver can be divided into the following blocks, whereby each has its own specifics:

- LNAs
- Mixers
- Crystal oscillators
- VCOs
- Clock Dividers
- PLLs
- Power amplifiers
- Baseband Processing

For each type of RF cell a customized measurement configuration is required and the appropriate measuring procedure must be implemented. It is here in particular that a clear standardization and simplification of the test program and data management is made possible with the help of modular test systems. For an appropriate test circuit design (design for test), it is important that all the layout variations correspond to a defined standard, which specifies the location of the RF and ground pins.

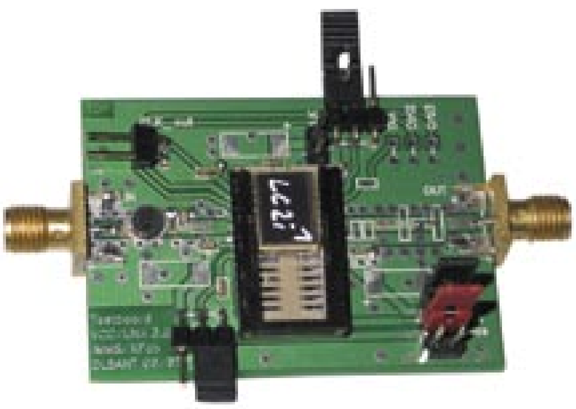


Figure 1: Evaluation Board for VCOs and LNAs with SMD socket for SOIC-16 package

This makes it possible to metrologically treat all RF cells on one and the same hardware platform. The standard layout allows the evaluation from LNAs, mixers and VCOs/PLLs to PAs (see figure 1). This can also create a uniformly defined interface to the measurement equipment. Current projects address the frequency range between 900 MHz and 2.4 GHz. Future developments will be in the range of 5 to 10 GHz, which in turn will place new demands on the measuring environment.

The PXI test systems used at the IMMS are equipped with the appropriate plug-in cards to meet these requirements. Moreover, these cost only a fraction of a complete external measuring device and save additional space and energy.

According to the specification, the following types of measurements have been implemented:

- S-parameter measurements
- Spectral analysis
- Noise measurements
- Transient measurements
- Large signal measurements
- DC measurement

Especially by the DC measurements the challenge the IMMS faced was to measure standby currents down to within the nA range in a reproducible manner. Also, the spectral purity of the power supply is a very critical parameter in PLL and VCO measurements.

The above-mentioned measurement types were conducted both single-ended and differential. Whereby measurements of differential symmetric RF parameters are only possible with external hardware and/or corresponding software modules.

Also the various measurements on-wafer and on PCB were implemented. Whereby in the case of on-wafer measurements instead of the evaluation board, a probe card or an arrangement of RF and DC needles is required (see figure 2).

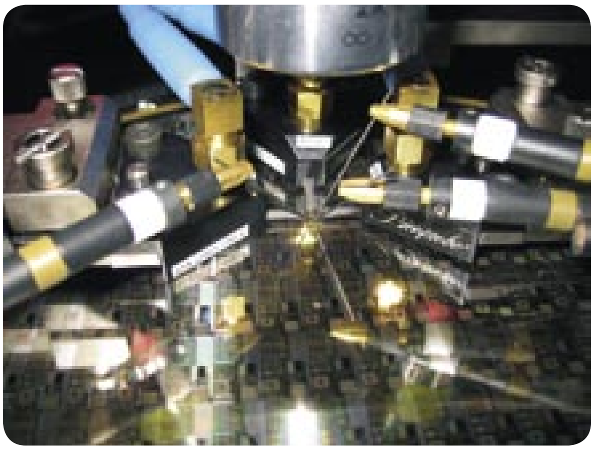


Figure 2: Contacting of the mixer on-wafer using three ACP probes

Development of Modular Test Systems

In addition to the available PXI cards, such as:

- RF down converter and digitizer
- RF signal generators
- Relay driver
- Digital cards
- Power supply

Also own PXI cards have been developed to expand the measurement possibilities. As an example, a PMU card [11], which can be used as a 32-channel source meter, is cited here. It was thus possible to conduct a connection test with 32 pins and to ensure a low noise power supply of the VCO. Outstanding is the fact that as a result power flows down to less than 1 nA could be measured, what was hitherto not possible at PXI level. Furthermore, this card can also be used as a 32-channel digital multimeter. This system extension was also supplemented by the use of optimized RF switches for measurement port switching. By using this compact, expandable – really modular – test system, the measurement tasks in the range of up to 2.4 GHz could be realized. Furthermore, through the multiplexing of the measurement signals it was possible to save test resources.

The use of configured modular PXI test systems at the IMMS offers a multitude of advantages:

- Compact equipment arrangement
- Clear, short wiring
- Integration of different measuring cards
- Significantly shorter measuring times
- Flexible measuring data management
- Modular complex measuring processes
- Special measurements in Software
- Space and energy savings
- Faster program development
- Reusability of programs
- Flexible scalability/extensibility
- Possibility of online data analysis

Summary

At the IMMS a modular hardware and software platform for the characterization of RF cells through measurements on PCBs and on-wafer was developed. In the center of this development work were modular PXI test systems, which were supplemented by own hardware and software modules. The system of hardware and software is distinguished by its modularity and reusability. Development time can hereby be significantly shortened. Furthermore, the use of fully documented standard RF assembly blocks accelerates the design process for custom applications. Also, due to the uniform measurement platform, the comparisons among different technological solutions is simplified. The defined measurement environment increases the reproducibility of measurement conditions and hence also the results. This leads to a simplified data management. The statistical analysis and visualization of results also provides important information for a secure and effective circuit design.

Björn Bieske, Project Manager RF Systems, Industrial Electronics and Measurement Technology, bjoern.bieske@imms.de

Flexibly Configurable PXI Test System

Design and Use Experiences for On-wafer Measurements in the Semiconductor Sector

„The main focus thereby was on a high reusability of assembly components and the resulting lower costs due to the adaptation to different types.“

In the context of the project OCTOPUS a flexible configurable PXI test system for on-wafer measurements was designed and evaluated at the IMMS.

The detailed objectives in the design of the test systems were the integration of commercially available components and proprietary developments in joint testing platforms, a high test design speed and the simple and standardized adaptability of various – both existing as well as new yet to be developed – probe cards. The main focus thereby was on a high

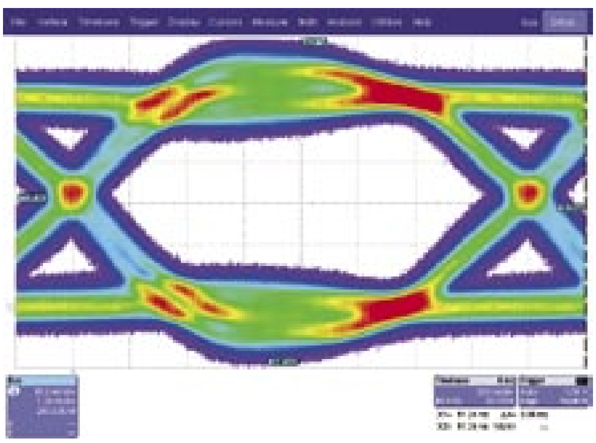


Figure 1: Characteristic of the transmission of a testing channel

reusability of assembly components and the resulting lower costs due to the adaptation to different types. Furthermore, a reduction in measurement times was envisaged that would in future contribute to ensuring the provision of efficient and cost-optimal test solutions for research and industry partners in the microelectronics and microsystems technology sector.

Technical Implementation

The PXI chassis that was enhanced by the ABex system (Analog Bus EXtension for PXI) of the project partner Konrad Technologies serves as a basis for the test systems used at the IMMS. It is an electronic and mechanical expansion of a PXI system, and offers the possibility to use on each of the PXI instruments, either an existing project-specific or designed terminal module. In addition, it provides both the analog and digital lines that are used between the terminal modules. This ensures not only the controllability and communication of the modules but also their mechanically secure attachment. On the basis of specially developed terminal modules, the IMMS has realized an intermediate layer, which allows the adaptation of the different testing instruments, on the shared bus system.

Concept of the Bus System and the Terminal Modules

In order to achieve the goal of basically being able to route each instrument on any measuring channel, each terminal module must attain access to the entire measuring channel bus. The deployed bus system consists of 200 lines, namely 100 signal lines and 100 ground lines which are led vertically through plug connectors to the terminal modules.

Figure 2: Terminal modul block

The open line ends are therefore only as long as needed for the envisaged number of instruments. There is a special terminal module at the end of the bus, which carries out the desired channel mapping of the access lines to the wafer probe or to the probe card.

Each terminal module can be individually adapted from the side of the PXI system to the respective test instrument. The channels provided by the instruments vary from one to well over a 100 signals. The bus and modular architecture makes it possible to switch several instruments to a measuring channel. The necessary control for relays or electronic switches is provided on the module. Each module has a microcontroller that communicates with the test control over the I^2C Bus that is provided by the ABex. The detection of the used terminal modules and their addresses, or installation positions in the system is fully automated, through the use of the ABex controller. Fast and pre-programmed switching sequences of the channels are made possible through the use of a microcontroller. In addition, each module has its own intelligence, which offers a very high flexibility and adaptability to future test tasks.

The terminal module architecture provides possibilities to change and influence the signals to and from an object that is to be measured and thus leads to the targeted optimal use of the properties of the PXI instruments.

The terminal modules entail only the signal switches, and signal conditioning. The assignment for the bus is performed by hard-wired, project-specific encoding boards. These boards neither have their own logic, nor do they entail any expensive assembly components and are in addition also relatively small.

Terminal Modules for High-Speed Digital and Analog Test

To evaluate the presented concepts, the IMMS designed a terminal module for each – a PXI-PMU instrument (developed in the IMMS respectively) and for a high speed digital IO interface PXI-6552. The two modules were as far as possible kept identical, in order to limit the effort put into the layout.

The outputs of the PMU on the terminal module are initially led over a terminal block and a relay switching block, before the signals are passed on via a hard-wired matrix encoder. Here the project-specific mapping of the PMU channels to the channels of the measuring system takes place.

The signals of the HSDIO PXI-6552 are transmitted to the terminal module and there led into a relay switching block within a 50 ohm system that has the same routing length for each channel. Thereafter, the signals are similarly again mapped on to an encoding board of the measurement channel.

To a large extent the identities of the terminal modules, thereby most especially the relay control and the microcontroller, among others also enable unified software architecture of the firmware on different terminal modules. The driver software in the test system can also consequently be developed not only very efficiently but also quickly.

Coordination of the Test System and Wafer Probe

The PXI test system is designed to interact with the control software Prober Bench of the probe-station PA200 from the manufacturer SÜSS MicroTec AG. The test system is hereby connected via a TCP/IP-connection to the control computer of the probe-station. The Prober Bench software works with this connection as a server over which the test system assumes the capacity of a client and can as a result execute the functions of the probe-station. The SÜSS Network Interface (SNI) API provided by software is hereby used.

It is possible over the remote control of the prober, to approach and test the dies of a wafer that have been automatically selected by the test program. For all other purposes, the functions of the Prober Bench can also be used. Thus, for example, based on the test results, BIN classifications can be entered into the wafer maps. This control enables among other things, an automated test sequence on a wafer and thus the cost-effective realization of small serial tests.

Summary and Outlook

The architecture of the IMMS test system has fulfilled all the specified expectations within the framework of the first trials. Especially the simple integration of additional PXI instruments in the concept makes it possible to configure quick and at the same time cost effective solutions for complex testing tasks.

A future goal in the further development of the test system is the realization of the in-system programming of the firmware of the terminal modules. The properties and behavior of the modules could consequently be expanded and improved without removal. This would also lead to a significant reduction of the changeover time for different test projects.

After the completion of the project, the designed test systems will be used by the industrial partners of the IMMS.

The project OCTOPUS was funded by the BMBF, project number 13N10345.

Dipl.-Ing. Ingo Gryl, Scientific Staff Member,
Industrial Electronics and Measurement Technology,
ingo.gryl@imms.de

Improving the Test Quality for Optoelectronic Circuits

„By the use of photodiodes in multimedia applications the demands on the speed and sensitivity of the optoelectronic integrated circuits, particularly with respect to the photodiodes embedded therein are becoming increasingly larger.“

By the use of photodiodes in multimedia applications, such as reading and writing devices for CD, conventional DVD and advanced Blu-ray DVD the demands on the speed and sensitivity of the optoelectronic integrated circuits, particularly with respect to the photodiodes embedded therein are becoming increasingly larger. The research on the laser beam is an important integral part by the characterization of such systems. To this end a laser measuring head has hitherto been used. Thereby measurement problems also arise that can be remedied by a transfer of the beam characterization to the wafer level.

By the hitherto implemented methods a laser scanner has been used, which is a separate assembly part and serves as an external measuring device. By the new procedure implemented at the IMMS, new test structures are designed and processed directly on the wafer. This means, the beam characterization is possible even in the wafer probe itself. The beam characterization carried out in this manner corresponds to the same conditions surrounding the measurement of optoelectronic chips on the wafer prober.

Characterization of the Laser Beam Profile

Measuring of beam profile with laser scanner (25 µm-slit)
(zoom10x, 400 nm, 543.2 µW)

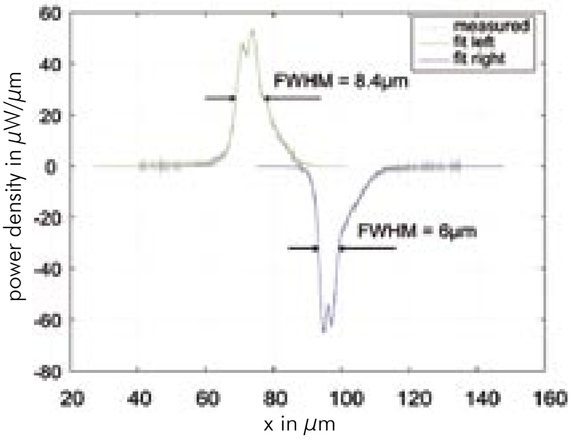


Figure 1: Example scan with the BeamScope-P7 for a beam profile on the microscope objective (λ=400nm)

To measure the transverse beam profile of the laser used at the IMMS, the laser scanner BeamScope-P7 has hitherto been used. Therein is a finger that is periodically retracted and extended. Set on the finger are two photodiodes next to each other. These are shaded by a glass cover and only through its integral slits can light get to the photodiodes. The available slits have the dimensions of 2.5 µm or 25 µm. The laser profile is thus measured in two dimensions.

The hitherto used wafer prober of the IMMS, tests integrated circuits primarily with photodiodes at the wafer level. To this end an optical signal from one fiber is coupled into the microscope. A convex lens in the microscope collimates the light from the fiber. The thus resulting parallel beam path is then focused by the objective of the microscope on the wafer surface. For the testing of the laser spot, in place of a wafer the laser scanner was positioned on the chuck under the objective of the microscope. Figure 1 shows an example scan for a real laser spot that was measured by the laser scanner using the 25 mm wide slit.

By the use of the laser scanner the following disadvantages manifested themselves. The range of the laser spot size varies over the distance between the lens and Chuck from about 0.5 µm to 30 µm. Different slit widths are thereby required, which are complex to replace on the laser scanner. The light due to real construction does also not hit the slits of the laser scanner at the same angle as on the wafer. As a result this leads to two distinct laser profiles of the wafer and the laser scanner. In addition, the height difference between the laser scanner and wafer surface is too large, variable and measurable only with considerable effort. Ultimately, this speaks for a transfer that makes it possible to position the variable slits on the wafer in a small space next to each other, whereby the spacing between the slits in the µm range will then be significantly smaller. The transfer of the measuring principle to the wafer level was therefore an important step.

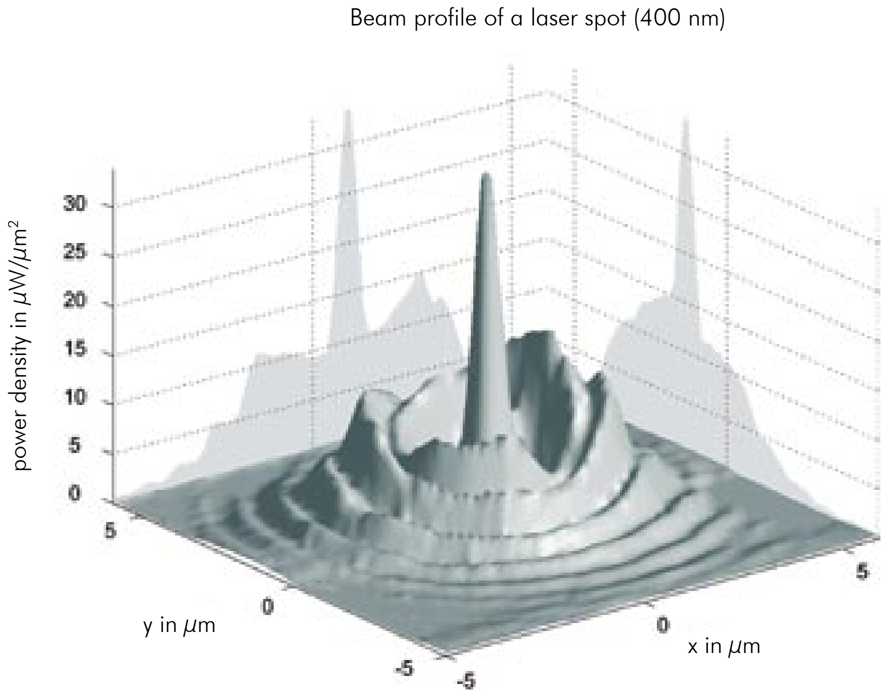


Figure 2: Beam profile of the laser image on the wafer for λ = 400 nm measured through the scanning of the hole

Solution – Transfer to the Wafer Level

The aim is to measure the beam profile on the wafer by the optoelectrical characterization of integrated circuits. The use of a laser scanner is therefore due to its disadvantages obsolete. The simplest structures for the characterization of the beam profile are slits, edges and holes in optically opaque layers over an optically sensitive surface, such as photodiodes. The various structures were tested in several setups. Edges have the advantage that by directing the entire beam profile on the optically sensitive surface, the entire optical power of the profile can be measured. However, for the actual beam profile the measured curve must be differentiated (see figure 1). This thereby deteriorates the signal to noise ratio. The profile is measured directly when passing over the slits, but the thereby transmitted power through the slits decreases. Depending on the actual power density a decision has to be made in the future as to which of the structures will be used for beam measurement.

According to the principle of one-dimensional scans over a slit, the possibility of a two-dimensional measurement of the laser profile through the scanning of a hole also arises (see figure 2).

Conclusion

So far, the power density of a laser beam profile was measured with the help of a laser scanner. The transfer of the measurement to the wafer level will have the following advantages: In addition to the finer and more visible profile positioning of the laser profile on the diode surface, the spatial dependencies of the sensitivity of the diodes on the wafer level can also be detected and accurately analyzed. This results in addition to the cost and time savings for the manufacture of cased assembly components also to space savings for smaller test structures on the wafer. Also, the change in temperature on the wafer through the temperature chuck is easily feasible.

Any structures, such as holes, slits and edges with different dimensions are necessary and can be realized and used in the smallest space. In the vicinity of the AUT (Application Under Test) optoelectronic circuit structures, structures for the characterization of the beam profile with minimal space requirements are envisaged. By sufficient power density the use of slits or holes is recommendable, otherwise edges should be used.

A key task at the IMMS is the characterization of optoelectronic circuits. These include, inter alia, the local optical sensitivity of photodiodes. Examples are the crosstalk of two adjacent photodiodes, the local variable sensitivity on the stripe diodes and the minimal size of photodiodes by the measurement of transmission bandwidth. For the first time the two-dimensional beam profile of the used laser can be measured with the newly developed test structures at the IMMS that have been described here. The resulting findings are an essential component in the further development of optoelectronic measuring technology in regard to the characterization of technologies with lower structural dimensions.

Dipl.-Ing. Marco Reinhard, Scientific Staff Member, Industrial Electronics and Measurement Technology, marco.reinhard@imms.de

Photo Detector IC for Blu-ray Disc Drives with 12 fold Read/Write Speed

„To write and read a complete Blu-ray Disc within a few minutes, high speed drives with consequently very fast electronic components are required.“

Figure 1: Image comparison DVD (left) and Blu-ray Disc (right) – high-definition images show more details

In 2008 the leading Hollywood film studios selected Blu-ray Disc as their single distribution media for commercial high-definition (HD) video films. Since then, the Blu-ray Disc system has established itself worldwide as the successor of the DVD in the consumer electronics market. Just like DVDs, Blu-ray Discs are read optically using a focused laser beam; however, the Blu-ray Disc system uses blue laser light rather than red light for higher disc capacity – almost five to ten times the capacity of a DVD. The range of available media types for both systems is comparable: the most significant media types for Blu-ray Discs are the BD-ROM format, mainly used as read-only distribution media for commercial HD video of up to four hours of playing time, and the BD-RW format as rewritable media for consumer use.

Due to their high storage capacity of up to 50 gigabytes, rewritable Blu-ray Discs are of particular interest as low-cost media for archiving computer data. However, recording such amounts of data should take much less time than playing back a movie. This requires high-speed drives that are capable of writing and reading a complete Blu-ray Disc within a few minutes instead of several hours. Consequently, the electronic components in these drives have to support data transfer rates in excess of ten times the rate needed for HD video playback.

One of the key components in the read path of the drive electronics is a small chip named PDIC (Photodetector Integrated Circuit). The PDIC converts the high-frequency laser light pulses reflected by the Blu-ray Disc into electrical signals, from which the stored data can be recovered. In a collaborative industrial research project funded by the State of Thuringia, Germany, IMMS has developed a PDIC that is capable of reading Blu-ray Discs up to 12 times faster than conventional HD video speed – this corresponds to the current maximum possible rotation speed of Blu-ray Disc drives. The particular challenge faced in the development of the PDIC was to meet the extreme bandwidth requirements for the signal amplifier chain (greater than 300 MHz) while minimizing noise to preserve a good signal quality.

Implementation of the PDIC

The 12x Blu-ray Disc PDIC D3001 developed by IMMS processes the light signal received by a photodiode array in a multistage amplifier chain. From a number of possible system architectures, a four-stage amplifier chain was selected. Its first two stages consist of current amplifiers for the photodiode currents. Compared to an architecture based on transimpedance amplifiers, the four-stage architecture allows the various gain settings required by the drive manufacturers to be configured very efficiently during operation by switching the current amplifier gains. These gain settings as well as the different operating modes of the PDIC can be configured electronically over an I^2C-interface.

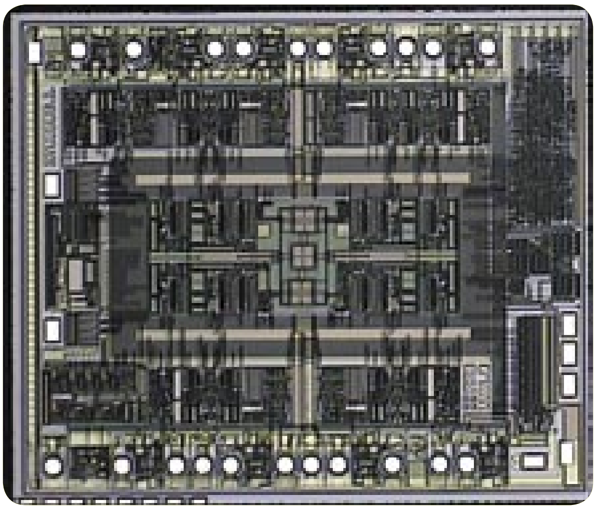


Figure 2: Chip photo of the PDIC

In order to ensure a low offset error of the amplifier chain (< 10 mV) despite the expected parameter variations from the semiconductor manufacturing process, chip-internal trimming circuitry was included. In addition, the trimming circuitry allows the bias current of the PDIC and its gain to be adjusted electrically. An integrated DfT circuit (design for test) enables an easy and fast production test. To reduce RF signal distortion on the flex cable usually attached to the PDIC, all fast outputs were matched to the cable impedance of 110 Ω. The chip layout was created using a systematic star wiring approach for the power supplies of the individual blocks. Its performance was verified using an accurate extraction of the parasitic resistances and capacitances. The PDIC D3001 was implemented on a chip area of 5.72 mm^2 using the XB06PIN process from X-FAB Semiconductor Foundries AG.

Figure 2 shows a photograph of the chips produced by the X-FAB. Three four-quadrant detectors are visible in the middle of the photodiodes fields, whereby a single photodiode in each case occupies an area of 50 x 50 μm^2. The amplifier chain stretches starting from the detector field from the inside to the outside. The output drivers are integrated in the respective pad cell. In the lower area of the photo, the logic for the I^2C interface and the circuit for trimming and test support (left) are visible. The PDIC is designed for installation in an 18-pin casing.

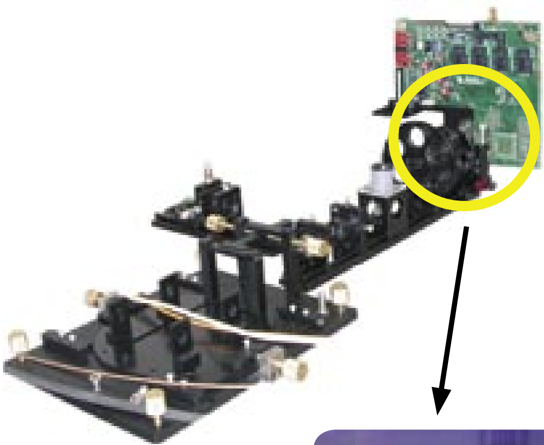


Figure 3: Optoelectronics measurement bench at the IMMS

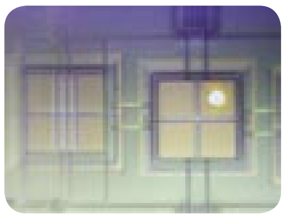


Image of the laser spot projected on the detector array of the PDIC

Measurement setup for photo detectors

Characterizing the performance of the manufactured PDIC requires measurement instrumentation that permits a fine laser spot with a diameter of 20 microns to projected onto the photodiode field with a positioning accuracy of less than 1 micron. A new optical measurement bench has been specially developed by IMMS for this purpose. It enables static and dynamic measurements of optoelectronic receiver circuits for signal frequencies up to 1 GHz. The device under test can be positioned automatically under computer control in three dimensions. At the same time, the position of the laser spot on the device under test can be observed with a camera for visual inspection of the test setup. Figure 3 shows the measurement bench and an image of the laser spot projected on the detector array of the PDIC.

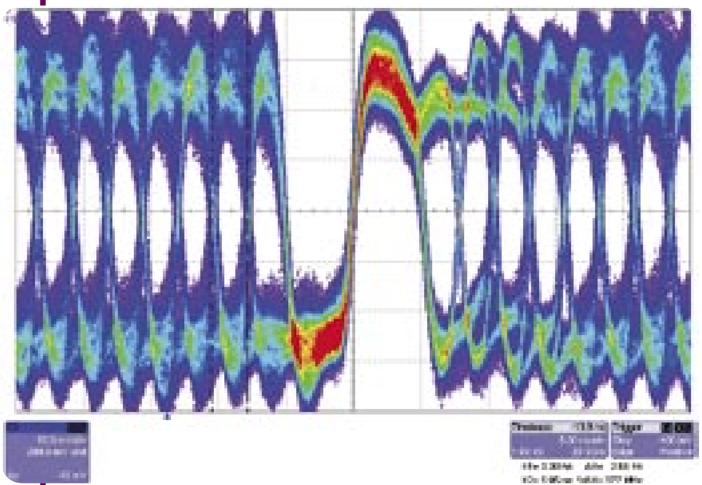


Figure 4: Eye diagram of a Blu-ray Disc-bit pattern (2T14T pattern on the differential output with a time period of 5.2 ns)

Measurement Results Confirm Leading-edge Performance

The dynamic behavior of the PDIC D3001 was measured under industrial test conditions. Figure 4 shows the response of the differential data signal output (RFP-RFN) to a 14-bit pseudo-random pattern sequence modulated onto the laser beam. The selected data patterns represent the typical conditions on a Blu-ray Disc. The minimum pulse width of the pattern is 2.6 ns, corresponding to 12 times the normal speed of the Blu-ray Disc system. Even in the operating mode with the highest gain, the eye diagram exhibits clear eye openings. The measured values for amplitude noise and jitter are 44 % and 0.6 ns, respectively. Our measurement results demonstrate that the PDIC will be capable of producing output signals of sufficient quality for successful data recovery even in the presence of high noise levels in the optical input signals.

Conclusion and Outlook

The photodetector IC D3001 is a complex data signal detector for use in high-speed Blu-ray Disc R/W systems, which has been successfully developed and characterized in our Institute. The PDIC D3001 is one of the few comparable ICs worldwide that support 12x Blu-ray Disc speed. It is thus particularly suitable for use in fast computer disk drives for data archiving. Through its modular structure, the layout is easily adaptable to other specifications regarding the detector array or the set of operating modes.

Acknowledgments

The work presented here was carried out within the collaborative industrial research project “Modeling and optimization of photodiodes and DVD front-end amplifier circuits” under project no. 2006 VF 0046, grant no. 2006 FE 0395. We thank the State of Thuringia and the Thüringer Aufbaubank for their support.

Dipl.-Ing. Holger Pleß, Project Manager
Optoelectronics, Microelectronic Circuit Design,
holger.pless@imms.de

Bibliography

[1] Alexander Müller; Selbstreferenzierendes Personalisiertes Miniaturisiertes Dosimeter (PMD) zur Bestimmung individueller Belastungs-Beanspruchungs-Beziehungen, Universitätsverlag Ilmenau, 2009

[2] Alexander Müller, Tobias Schmidt, Thomas Elste, Martin Sachs, Hannes Töpfer, Hartmut Witte; Schutz der Beschäftigten vor Gefährdungen durch Lärm im Sinne der Lärm- und Vibrations- Arbeitsschutzverordnung mithilfe Personalisierter Miniaturisierter Lärm-Dosimeter (PMD), Lärmbekämpfung, Zeitschrift für Akustik, Schallschutz und Schwingungstechnik, Nr. 3, Mai 2009

[3] Bundesgesetzblatt: Verordnung zur Umsetzung der EGRichtlinien 2002/44/EG und 2003/10/EG zum Schutz der Beschäftigten vor Gefährdungen durch Lärm und Vibrationen. Bonn: Bundesanzeiger, März 2007

[4] DIN-EN-61672-1: Elektroakustik – Schallpegelmesser, Teil 1: Anforderungen. Beuth Berlin: Deutsches Institut für Normung e.V., Oktober 2003

[5] Regionaler Wachstumskern CBS, URL: http://www.customerbautronic.de/, BMBF-Förderkennzeichen: 03WKBD3C, Angesehen am 15.12.2009

[6] IEEE 802.15.4, Wireless Medium Access Control (MAC) and Physical Layer (PHY), Specifications for Low Rate Wireless Personal Area Networks (LR-WPANs), 2004

[7] Rossbach T., Götze M., Cervakova E.; Architekturaspekte beim praktischen Einsatz drahtloser Sensornetzwerke, IWK Mittweida, 2008

[8] Hardware, URL: http://www.plogginternational.com/ploggproducts.html, Angesehen am 16.12.2009

[9] URL: http://www.atmel.com/products/zigbee/zigbit_modules.asp?family_id=676, Angesehen am 16.12.2009

[10] Gordeeva, A.; Thesis "Untersuchung zum energieeffizienten Betrieb von Sensorknoten", IMMS GmbH, 2009

[11] Alexander Rolapp, Roman Paris; Parametric Measurement Unit und Pinelektronik für ein modulares Mixed Signal Testsystem, TuZ 2009, Tagungsband S.86, 2009

Publications – Patents – Events

Publications

• Jörg Pospiech[1], Renaldo Holzapfel[1], Hannes Töpfer[2], Rolf Peukert[2], Karl-Heinz Nebel[1], **Kamera auf Bestellung**, S&I-Kompendium 2009, Videoüberwachung, Alarm- & Sicherheitssysteme, S.208, Januar 2009, www.sui24.net

[1]AVT GmbH, [2]IMMS GmbH

• Boyko Dimov, Volker Boos, Torsten Reich, Christian Lang, Eckhard Hennig, Ralf Sommer, **A novel technique for CAD-optimization of analog circuits with bipolar transistors**, Advances in Radio Science, 7, S.219-223, 2009

• Murat Isikhan, André Richter, **CMOS low-noise amplifiers for 1.575 GHz GPS applications**, Advances in Radio Science, 7, S.145-150, 2009

• Alexander Rolapp, Roman Paris, **Parametric Measurement Unit und Pinelektronik für ein modulares Mixed Signal Testsystem**, 21. Workshop „Testmethoden und Zuverlässigkeit von Schaltungen und Systemen" (TuZ 2009), Tagungsband S.86, 15.02.-17.02.2009, Bremen

• Michael Meister, Alexander Rolapp, Ingo Gryl, **Test opto-elektronischer Schaltungen unter Verwendung von PXI-Testsystemen**, 21. Workshop „Testmethoden und Zuverlässigkeit von Schaltungen und Systemen" (TuZ 2009), Tagungsband S.81, 15.02.-17.02.2009, Bremen

• Björn Bieske, **Test differentieller Parameter von HF-Komponenten im GHz-Bereich**, 21. Workshop „Testmethoden und Zuverlässigkeit von Schaltungen und Systemen" (TuZ 2009), Tagungsband S.35, 15.02.-17.02.2009, Bremen

• Conny Franke[1], Marcel Karnstedt[2], Daniel Klan[2], Michael Gertz[3], Kai-Uwe Sattler[2], Wolfram Kattanek[4], **In-Network Detection of Anomaly Regions in Sensor Networks with Obstacles**, 13. GI-Fachtagung Datenbanksysteme für Business, Technologie und Web, 02.03.-06.03.2009, Münster

• Conny Franke[1], Marcel Karnstedt[2], Daniel Klan[2], Michael Gertz[3], Kai-Uwe Sattler[2], Elena Chervakova[4], **In-Network Detection of Anomaly Regions in Sensor Networks with Obstacles**, Computer Science – Research and Development, Special issue "BTW 2009 Best Papers", Volume 24, Number 3, ISSN 1865-2034, Springer, 2009

[1]University of California, Department of Computer Science, Davis (USA), [2]TU Ilmenau, Databases and Information Systems Group (Germany), [3]University of Heidelberg, Institute of Computer Science (Germany), [4]IMMS GmbH (Germany)

• Steffen Michael[1], Klemens Brueckner[2], Florentina Niebelschuetz[2], Katja Tonisch[2], Christoph Schäffel[1], **Parameter Identification of Piezoelectric AlGaN/GaN Beam Resonators by Dynamic Measurements**, 10th EuroSimE 2009, 26.04.-28. 04.2009, Delft (Netherlands)

[1]IMMS GmbH, [2]TU Ilmenau, Institute of Micro- and Nanotechnologies

• Alexander Müller[1], Tobias Schmidt[1], Thomas Elste[2], Martin Sachs[2], Hannes Töpfer[2], Hartmut Witte[1], **Schutz der Beschäftigten vor Gefährdungen durch Lärm im Sinne der Lärm- und Vibrations-Arbeitsschutzverordnung mithilfe Personalisierter Miniaturisierter Lärm-Dosimeter (PMD)**, Fachzeitschrift Lärmbekämpfung, Springer VDI Verlag, 03.05.2009

[1]TU Ilmenau, Fachgebiet Biomechatronik, [2]IMMS GmbH

• Sven Engelhardt, Elena Chervakova, Wolfram Kattanek, Tobias Rossbach, **MSP/AVR-basierte HW/SW-Plattformen für Drahtlose Sensornetzwerke**, 10. Workshop Mikrocontroller-Applikationen/Eingebettete Systeme, Hochschule Mittweida, 14.05.2009, Mittweida

• Kay Gastinger[1], Karl H. Haugholt[1], Malgorzata Kujawinska[2], Michal Józwik[2], Christoph Schäffel[3], Stephan Beer[4], **Optical, mechanical and electro-optical design of an interferometric test station for massive parallel inspection of MEMS and MOEMS**, Paper 7389-56, SPIE Europe Optical Metrology, 14.06.-18.06.2009, München

[1]SINTEF (Norway), [2]Warsaw University of Technology (Poland), [3]IMMS GmbH (Germany), [4]Ctr. Suisse d'Electronique et de Microtechnique SA (Switzerland)

• Thomas Ortlepp[1], Torsten Reich[2], Ronny Stolz[3], **System design of a digital superconducting magnetic field sensor**, 54. Internationales Wissenschaftliches Kolloquium, 07.09.-11.09.2009, TU Ilmenau

[1]TU Ilmenau, Institute of Information Technology, [2]IMMS GmbH, [3]Institute of Photonic Technology, Quantum Detection Department, Jena

• Elena Chervakova[1], Daniel Klan[2], Tobias Rossbach[1], **Energy-optimized Sensor Data Processing**, 4th EuroSSC 2009, http://info.ee.surrey.ac.uk/CCSR/EuroSSC/2009/, Proceedings pp. 35-38, 16.09.-18.09.2009, The University of Surrey, Centre for Communication Systems Research, Guildford (UK)

[1]IMMS GmbH (Germany), [2]TU Ilmenau, Department of Computer Science & Automation (Germany)

• Ahmed Amar[1], Wolfram Glauert[2], **Basic Design Challenges for Logical Gates Using Non-Standard Technologies or Circuit Concept Approaches**, 3. GMM/GI/ITG-Fachtagung „Zuverlässigkeit und Entwurf", 21.09.-23.09.2009, Stuttgart

[1]IMMS GmbH, [2]Uni Erlangen-Nürnberg, Lehrstuhl für Zuverlässige Schaltungen und Systeme

• Sven Engelhardt, Elena Chervakova, Tobias Rossbach, **Wireless Sensornetzwerke mit Multisensorik in der Gebäudeautomation**, Wireless Technologies Kongress 2009, 29.09.-30.09.2009, Stuttgart

• Malgorzata Kujawinska[1], Kay Gastinger[2], Michal Jozwik[1], Karl H. Haugholt[2], Christoph Schäffel[3], Stephan Beer[4], **An interferometric test station for massive parallel inspection of MEMS and MOEMS**, Photonics Letters Of Poland, Vol. 1 (2), 2009

[1]Warsaw University of Technology (Poland), [2]SINTEF (Norway), [3]IMMS GmbH (Germany), [4]Ctr. Suisse d'Electronique et de Microtechnique SA (Switzerland)

• Katja Tonisch[1], Wael Jatal[1], Ralf Granzner[2], Mario Kittler[2], Uwe Baumann[3], Frank Schwierz[2], Jörg Pezoldt[1], **2H-AlGaN/GaN HEMTs on 3C-SiC(111)/Si(111) substrates**, 13. Internationale ICSCRM, 11.10.-16.10.2009, Nürnberg

[1]TU Ilmenau, Institut für Mikro- und Nanotechnologien, FG Nanotechnologie, [2]TU Ilmenau, Institut für Mikro- und Nanotechnologien, Fachgebiet Festkörperelektronik, [3]IMMS GmbH

• Jens Bräutigam, Marco Götze, **Workflow zur Abbildung von Reglermodellen auf eine DSP-Plattform mit Ethercat-Anbindung**, Wissenschaftliche Berichte, Wissenschaftliche Zeitschrift der Hochschule Mittweida, Band Informatik, 11. Informatik-Tag, Nr. 6, 2009, ISSN 1437-7624, 20. Wissenschaftliche Konferenz Mittweida, 28.10.-29.10.2009, http://www.htwm.de/tagungen/

• Roland Syba[1], Mario Hahn[2], **Fortschritte bei der Verifikation von hardwarenaher Software**, eda Newsletter des edacentrums, Projekt Herkules, 10/2009

[1]Melexis GmbH, [2]IMMS GmbH

• Dr. Volker Großer[1], Dr. Detlef Heydenbluth[2], Prof. Dr. Ralf Moos[3], Dr. Dirk Rein[4], Josef Sauerer[5], Dr. C. Thomas Simmons[4], Dr. Wolfgang Sinn[6], Prof. Dr. Roland Werthschützky[7], Prof. Dr. Jürgen Wilde[8], **Sensor-Trends 2014**, Trends in zukunftsorientierten Sensortechnologien, AMA-Fachverband für Sensorik e.V., 10/2009, Berlin

[1]Fraunhofer IZM Berlin, [2]TU Ilmenau, Institut Prozessmess- und Sensortechnik, Ilmenau, [3]Universität Bayreuth, Lehrstuhl für Funktionsmaterialien, [4]AMA Fachverband Berlin, [5]Fraunhofer IIS Erlangen, [6]IMMS GmbH, [7]TU Darmstadt, Institut für Elektromechanische Konstruktionen, [8]Universität Freiburg, Institut für Mikrosystemtechnik

• Steffen Michael, **Parameter Identification of MEMS Membrane and Beam Structures by Modal Analysis and Dynamic Measurements**, ANSYS Conference & 27. CADFEM Users´ Meeting, 18.11.- 20.11.2009, Leipzig

• Hannes Töpfer[1], Thomas Ortlepp[2], **Design infrastructure for Rapid Single Flux Quantum circuits**, Cryogenics Volume 49, Issue 11, 11/2009, 643-647, ISSN 0011-2275, www.elsevier.com/locate/cryogenics

[1]IMMS GmbH, [2]TU Ilmenau, Institute of Information Technology

Presentations

• Marco Reinhard, **Transfer der dynamischen Charakterisierung von Fotodioden auf Wafer-Ebene**, Multi-Nature Systems: Entwicklung von Systemen mit elektronischen und nichtelektronischen Komponenten, 7. GI/GMM/ITG-Workshop, 03.02.2009, Ulm

• Tobias Rossbach, Elena Chervakova, **Drahtlose Sensor-Aktor-Netzwerke**, Bericht zum Projekt CBS – Costumer Bautronic Systems, Arbeitsgruppe 3, Nutzerintegrierte operative Gebäudesteuerung FKZ BMBF-03WKBD3C, CeBit 2009, 02.03.2009, Hannover

• Klaus Förster, **PXI – basierte Testplattformen für die Halbleiterindustrie**, 9. ATE –Technologietag, 01.04.2009, Radolfzell

• Boyko Dimov, **Entwurf von SC-Schaltungen – Grundlagen und grundlegende Probleme**, 20. Mikroelektronik-Seminar, 02.04.2009, Erfurt

• André Puschmann, **Quantitative analysis of system initialization in embedded Linux systems**, Embedded Linux Conference 2009, 06.04.2009, San Francisco, CA (USA)

• Murat Isikhan, **A Novel Low-Voltage Bandgap Reference Topology**, 21. Mikroelektronik-Seminar, 16.04.2009, Erfurt

• Alexander Rolapp, Roman Paris, **Parametric Measurement Unit and Pin Electronics for modular Mixed Signal Test Systems, Chip, Packaging, Design, Simulation and Test** – International Conference, Workshop and Table-top Exhibition „Semiconductor Conference Dresden 2009" (SCD 2009), 29.04.-30.04.2009, Dresden

• Ingo Gryl, Volker Schulze, **Application of a Modular Test System for Mixed Signal Tests, Chip, Packaging, Design, Simulation and Test** – International Conference, Workshop and Table-top Exhibition „Semiconductor Conference Dresden 2009" (SCD 2009), 29.04.-30.04.2009, Dresden

• Ahmed Amar, Boyko Dimov, Christian Lang, Jacek Nowak, Torsten Reich, **Pre- und Postlayout Analysis of Switched-Capacitor Circuits**, 22. Mikroelektronik-Seminar, 30.04.2009, Erfurt

• Tobias Rossbach, **Das Internet der Dinge – Ipv6 in drahtlosen Sensor-Aktor-Netzwerken**, 4. Silicon Saxony Day, 12.05.-13.05.2009, Dresden

• Steffen Michael, **Test und Charakterisierung von MEMS mittels dynamischer Messung am Beispiel von Membranstrukturen und Resonatoren**, 4. Silicon Saxony Day, 12.05.-13.05.2009, Dresden

• Wolfgang Sinn, **GALILEO-Regionale Initiativen in Deutschland & Konvergenz zu anderen Innovationen**, 4. Silicon Saxony Day, 12.05.-13.05.2009, Dresden

• Torsten Erbe[1], Renè Theska[1], Astrid Frank[2], Frank Spiller[2], **Strukturauswahl von Positioniersystemen durch Betrachtung der Funktionstopologie**, VDI/VDE-Tagung „Mechatronik 2009", 12.05.-13.05.2009, Wiesloch

[1]TU Ilmenau, Institut für Maschinen- und Gerätekonstruktion, Fachgebiet Feinwerktechnik, [2]IMMS GmbH

• Sven Engelhardt, Elena Chervakova, Wolfram Kattanek, Tobias Rossbach, **MSP/AVR-basierte HW/SW-Plattformen für Drahtlose Sensornetzwerke**, 10. Workshop Mikrocontroller-Applikationen/Eingebettete Systeme, Hochschule Mittweida, 14.05.2009, Mittweida

• Thomas Elste, **Embedded Linux powering a mobile Audio Dosimeter**, CrossBorder Linux OpenSource Conference, 12.06.2009, Flensburg

• Pascal Febvre[1], Torsten Reich[1,2], Michel Auguste[3], Daniel Boyer[3], Alain Cavaillou[3], Georges Waysand[3], Rémi Blancon[4], Thomas Ortlepp[5], F. Hermann Uhlmann[5], Juergen Kunert[6], Ronny Stolz[6], and Hans-Georg Meyer[6], **Digital Magnetometers Based On the Single-Flux-Quantum Technique**, SSV2009-JSPS Joint Workshop, 15.06.-17.06.2009, Kyushu University, Fukuoka (Japan)

[1]University of Savoie, Institute de Microélectronique Electromagnétisme et Photonique and Laboratoire d'Hyperfréquences et de Cractérisation, Le Bourget du Lac Cedex (France), [2]IMMS GmbH (Germany), [3]Laboratoire Souterrain à Bas Bruit, La Grande Combe, Rustrel (France), [4]Université d'Avignon, Département de Physique, Avignon (France), [5]TU Ilmenau, Institute of Information Technology, Ilmenau (Germany), [6]Institute of Photonic Technology, Quantum Detection Department, Jena (Germany)

• Reinhard Kindt, **Arbeitsetappen, Erkenntnisse und Erfahrungen bei der Systematisierung des Entwurfs von zyklischen ADU in SC-Technik am IMMS (1999-2009)**, 28. Mikroelektronik-Seminar, 01.07.2009, Erfurt

• Volker Boos, **Tools zur Analyse, Dokumentation und Wiederverwendung von Schaltungstopologien**, 31. Mikroelektronik-Seminar, 15.07.2009, Erfurt

• Torsten Reich, **Post-Layout Optimierung unter Verwendung eines „Automatic Device Type Selection"-Algorithmus**, 33. Mikroelektronik-Seminar, 20.08.2009, Erfurt

• Murat Isikhan, **Tool-Unterstützung für „System in Package"**, 34. Mikroelektronik-Seminar, 03.09.2009, Erfurt

• Elena Chervakova, Tobias Rossbach, **Techniques and systems for indoor localization in wireless sensor networks**, 54. Internationales Wissenschaftliches Kolloquium 2009, 07.09.-11.09.2009, TU Ilmenau

• Tobias Rossbach, Axl Schreiber, Sven Engelhardt, Wolfram Kattanek, Elena Chervakova, **Long Life Sensor Moduls – Challenges for Hardware Design and MAC Algorithms**, 54. Internationales Wissenschaftliches Kolloquium 2009, 07.09.-11.09.2009, TU Ilmenau

• Björn Bieske, Klaus Gille, **Design and Characterization of RF Cells and RF ICs using different Technologies up to 6 GHz**, 54. Internationales Wissenschaftliches Kolloquium 2009, 07.09.-11.09.2009, TU Ilmenau

• Wei Wu, **3D-EM-Simulation als Entwurfsunterstützung**, 35. Mikroelektronik-Seminar, 09.09.2009, Erfurt

• André Richter, **Der Weg von Mess-/Simulationsergebnissen zum Modell (Model Order Reduction)**, 36. Mikroelektronik-Seminar, 15.09.2009, Erfurt

• Michael Meister, Dirk Nuernbergk, **Neue Teststrukturen zur Messung von Matching und Alterung an MOS-Transistoren**, Zuverlässigkeit und Entwurf (ZuE 2009), 21.09.- 03.09.2009, Stuttgart

• Wolfgang Sinn, **GALILEO-Regionale Initiativen in Deutschland & Konvergenz zur Identifikation**, Wissenschaft trifft Logistik, 21.09.2009, Erfurt

• Dagmar Kirsten, **Analogwertspeicherung mit Floating-Gates - Speicherzellen und Anwendung**, 37. Mikroelektronik-Seminar, 24.09.2009, Erfurt

• Malgorzata Kujawinska[1], Kay Gastinger[2], Michal Jozwik[1], Karl H. Haugholt[2], Christoph Schäffel[3], Stephan Beer[4], **An interferometric test station for massive parallel inspection of passive and active M(O)EMS**, 3rd Topical Meeting on Optical Microsystems, 27.09.-30.09.2009, Capri

[1]Warsaw University of Technology (Poland), [2]SINTEF (Norway), [3]IMMS GmbH (Germany), [4]Ctr. Suisse d'Electronique et de Microtechnique SA (Switzerland)

• Sven Engelhardt, Elena Chervakova, Tobias Rossbach, **Wireless Sensornetzwerke mit Multisensorik in der Gebäudeautomation**, Wireless Technologies Kongress 2009, 29.09.-30.09.2009, Stuttgart

• Norbert Zeike, Christoph Schäffel, Frank Spiller, **Planare hochdynamische Direktantriebe für den Sub-µm-Bereich mit großen Verfahrwegen**, ETG-Kongress 2009, Direktantriebe in Produktionsmaschinen und Industrieanlagen – Generatoren und Antriebe in regenerativen Kraftwerken, 27.10.-28.10.2009, Düsseldorf

• Wolfgang Sinn, **Wege in die Zukunft - Der Fahrplan zum Erfolg**, ELMUG Best-Practice-Workshop, 28.10.2009, Ilmenau

• Eckhard Hennig, **Design and Optimization of a High-Speed Blu-ray-Disc Photodetector IC**, MunEDA User Group Meeting 2009 (MUGM2009), 12.11.-13.11.2009, München

• Dominik Krauße[1], Eric Schäfer[2], Jacek Nowak[2], Ralf Sommer[2], Eckhard Hennig[2], **Analysis of Frequency-optimized Transimpedance**

Amplifiers in X-FAB 600nm BiCMOS Technology, MunEDA User Group Meeting 2009 (MUGM2009), 12.11.-13.11.2009, München

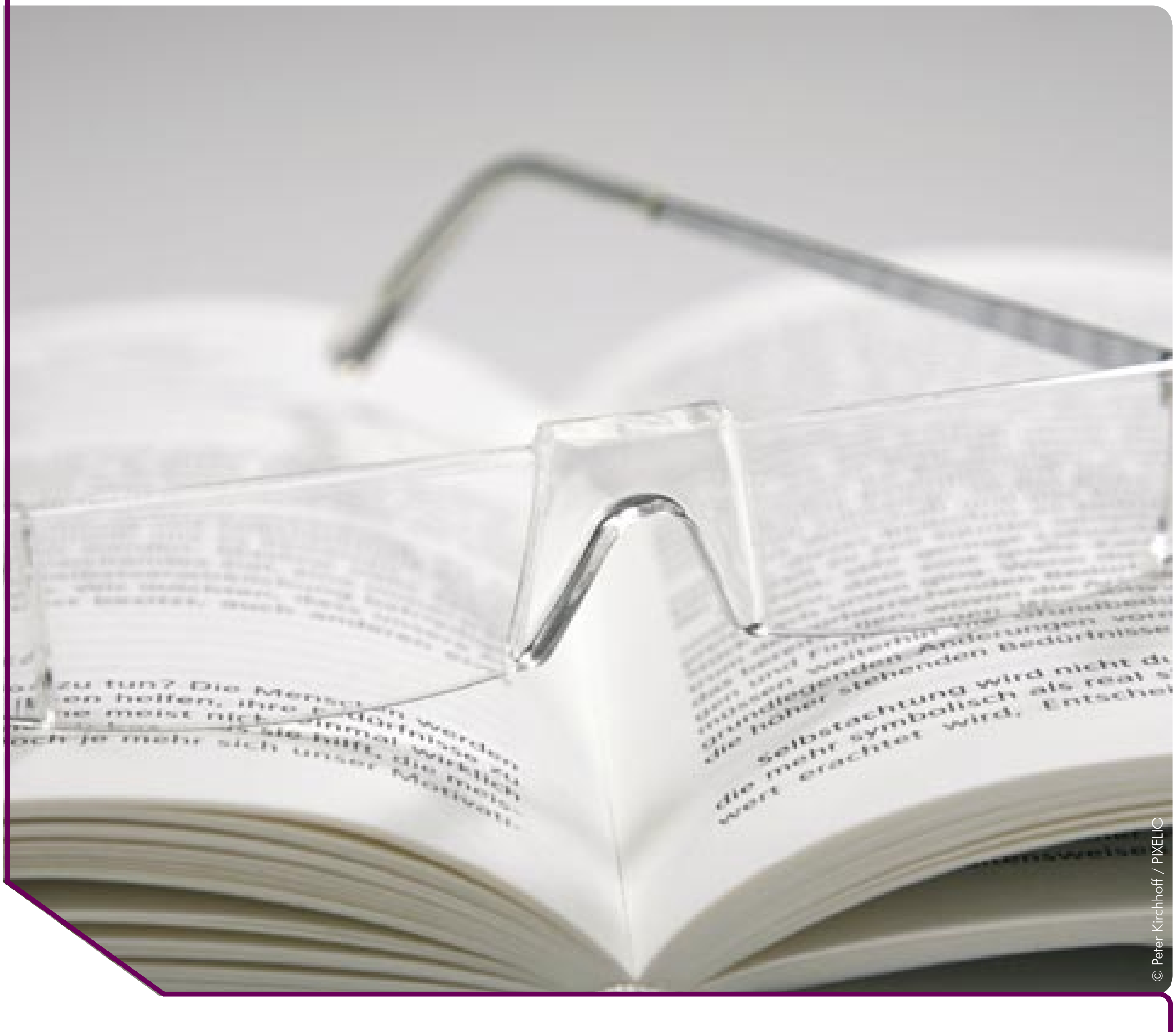
[1]TU Ilmenau, Fachgebiet Elektronische Schaltungen und Systeme, [2]IMMS GmbH

• Jun Tan, **„Entwurf eines schnellen Operationsverstärkers in einer 0,35-μm CMOS Technologie“**, 40. Mikroelektronik-Seminar, 16.11.2009, Erfurt

• Wolfgang Sinn, **Entwicklungstrends von Sensortechnologien**, 2. ELMUG-Branchentag, 18.11.2009, Erfurt

• Wolfgang Sinn, **Verkehr und Logistik - Zukunftsprojekte für RFID**, 3. Dresdner RFID-Symposium, 10./11.12.2009, Dresden

• Torsten Reich, Boyko Dimov, Christian Lang, Volker Boos, Eckhard Hennig, **A Post-Layout Optimization Method With Automatic Device Type Selection for BiCMOS Analog Circuits**, International Conference on Electronics Circuits and Systems, 13.12.-16.12.2009, Hammamet, Tunesien



Posters

- Steffen Hesse, Christoph Schäffel, **DFG Begutachtung, SFB 622 "Nanopositionier- und Nanomesssysteme", Teilprojekt A5, Nanopositioniersysteme großer Bewegungsbereiche, Forschungsergebnisse 2005-2009**, 11.02.-12.02.2009, TU Ilmenau

- Steffen Hesse, Christoph Schäffel, **DFG Begutachtung, SFB 622 "Nanopositionier- und Nanomesssysteme", Teilprojekt A5, Nanopositioniersysteme großer Bewegungsbereiche, Forschungsziele 2009-2013**, 11.02.-12.02.2009, TU Ilmenau

- Ingo Gryl, Volker Schulze, **Einsatz eines Modularen Test-Systems für Mixed Signal Tests**, 21. Workshop „Testmethoden und Zuverlässigkeit von Schaltungen und Systemen" (TuZ 2009), Tagungsband S.129, 15.02.-17.02.2009, Bremen

- Dagmar Kirsten, Volker Schulze, Dirk Nuernbergk, **One-step autozeroing two-stage amplifier with floating-gate memory cells**, DATE 2009, 20.04.-24.04.2009, Nizza, France

- Volker Boos, Ralf Sommer, Eckhard Hennig, **Gaining Insight into Analog Circuit Behavior – Tools and Extensions to Cadence DFII**, CDN-Live! EMEA 2009 Conference, 18.05.-20.05.2009, München

- Volker Boos, **Tools zur Dokumentation und Wiederverwendung von Schaltungstopologien**, edaWorkshop09, 26.05.-28.05.2009, Dresden

- Elena Chervakova, Tobias Rossbach, **Techniques and systems for indoor localization in wireless sensor networks**, 54. Internationales Wissenschaftliches Kolloquium 2009, 07.09.-11.09.2009, TU Ilmenau

- Elena Chervakova[1], Daniel Klan[2], Tobias Rossbach[1], **Energy-optimized Sensor Data Processing**, 4th EuroSSC 2009, 16.09.-18.09.2009, Centre for Communication Systems Research, The University of Surrey, Guildford, UK

[1]IMMS GmbH (Germany), [2]TU Ilmenau, Department of Computer Science & Automation (Germany)

- Jens Bräutigam, Marco Götze, **Workflow zur Abbildung von Reglermodellen auf eine DSP-Plattform mit Ethercat-Anbindung**, Wissenschaftliche Berichte, Wissenschaftliche Zeitschrift der Hochschule Mittweida, Band Informatik, 11. Informatik-Tag, Nr. 6, 2009, ISSN 1437-7624, 20. Wissenschaftliche Konferenz Mittweida, 28.10.-29.10.2009, Mittweida

- Norbert Zeike, Christoph Schäffel, Volker Bornmann, **Spezifische Entwicklung von Linearmotoren**, IENA Internationale Fachmesse „Ideen-Erfindungen-Neuheiten", 05.11.-08.11.2009, Nürnberg

- Murat Isikhan, Torsten Reich, André Richter, Eckhard Hennig, **A New Low Voltage Bandgap Reference Topology**, International Conference on Electronics Circuits and Systems, 13.12.-16.12.2009, Hammamet (Tunesien)

Patents

- Steffen Richter, Dirk Nuernbergk, Sonja Richter, Dagmar Kirsten, **EEPROM-Speicherzelle und ihr Auswahltransistor**

- Christoph Schäffel, Volker Bornmann, Dominik Karolewski, Michael Katzschmann, Jorge-Amado Whittingham-Gonzalez, **Linearantriebsanordnung mit feststehendem Magnetkreis und stromdurchflossener, bewegter Spule**

• Christoph Schäffel, Volker Bornmann, Michael Katzschmann, Dominik Karolewski, Jorge-Amado Whittingham-Gonzalez, **Vorrichtung und Verfahren zum Detektieren der Reibungen in Führungen**

• Christoph Schäffel, Volker Bornmann, Michael Katzschmann, Dominik Karolewski, Thorsten Maaß, **6D Messsystem**

• Christoph Schäffel, Norbert Zeike, Frank Spiller, Hans-Ulrich Mohr, Steffen Hesse, Volker Bornmann, **Feldgeführter planarer Präzisionsantrieb mit einem luftgelagerten Läufer**

• Christoph Schäffel, Norbert Zeike, Frank Spiller, Hans-Ulrich Mohr, Steffen Hesse, Volker Bornmann, **Präzisionsplanarpositionieranordnung**

• Christoph Schäffel, Norbert Zeike, Ulrich Preisser, Jürgen Heise, **Präzisionslinearantrieb**

Dissertations

• Torsten Reich, **Development of a digital SQUID magnetometer for widely varying fields in urban environment**, Oktober 2009, TU Ilmenau

Events

embedded world Messe,
03.03.-05.03.2009, Nürnberg

CeBIT,
02.03.-06.03.2009, Hannover

Hannover Messe, OSADL- Konferenz „Open Source meets Industry",
22.04.2009, Hannover

Bonding,
04.05.2009, Dresden

4. Silicon Saxony Day,
12.05.-13.05.2009, Dresden

Sensor+Test – Messtechnik-Messe,
26.05.-28.05.2009, Nürnberg

54th IWK – Internationales Wissenschaftliches Kolloquium, TU Ilmenau,
07.09.-10.09.2009, Ilmenau

Wirtschaft trifft Wissenschaft, TU Ilmenau
23.09.2009, Ilmenau

MNT-Fachmesse,
19.10.2009, Erfurt

Inova,
20.10.-21.10.2009, Ilmenau

IENA – Internationale Fachmesse „Ideen – Erfindungen – Neuheiten",
05.11.-08.11.2009, Nürnberg

Lange Nacht der Wissenschaft,
06.11.2009, Erfurt

Branchentag ELMUG,
18.11.2009, Erfurt

SPS/IPC/Drives 2009 – Elektrische Automatisierung – Systeme und Komponenten,
24.11.-26.11.2009, Nürnberg

PRECISION FAIR 2009,
ELMUG-Gemeinschaftsstand,
02.12.-03.12.2009, Veldhoven / Eindhoven (NL)

Innovationstag Thüringen,
08.12.2009, Erfurt

IMMS Team

The IMMS-Team

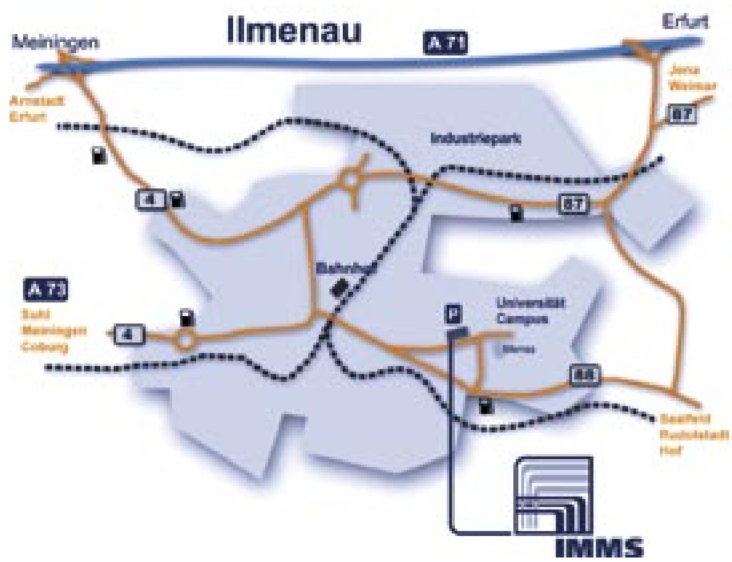
WE KNOW HOW.

www.imms.de

How to find us – Contact

Institut for Microelectronic and Mechatronics Systems GmbH

Ehrenbergstr. 27
D - 98693 Ilmenau/Thüringen/Germany
Phone: +49 (3677) 69 55 00
Fax: +49 (3677) 69 55 15
E-Mail: imms@imms.de



Branch office Erfurt
Konrad-Zuse-Strasse 14
D - 99099 Erfurt/Thüringen/Germany
Phone: +49 (361) 663-2500
Fax: +49 (361) 663-2501
E-Mail: imms@imms.de

tram #3, from central station direction „Urbicher Kreuz“
exit at stop „Windischholzhausen/X-FAB“