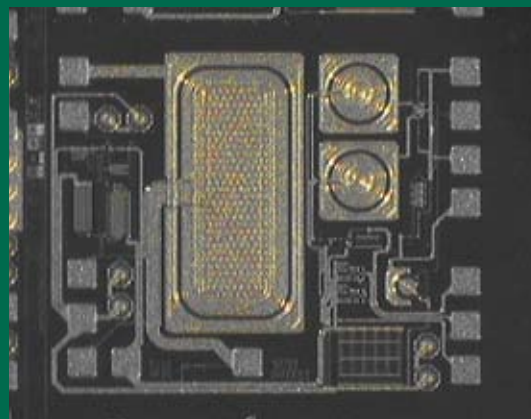
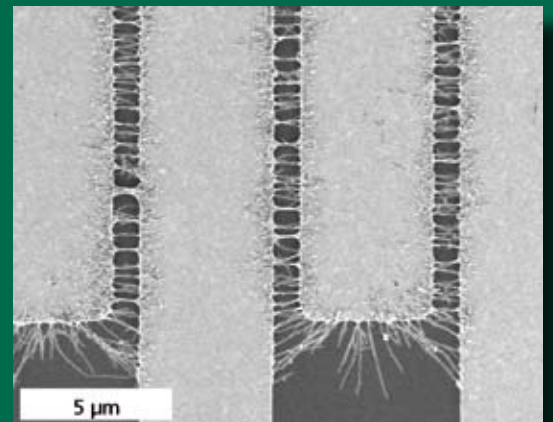
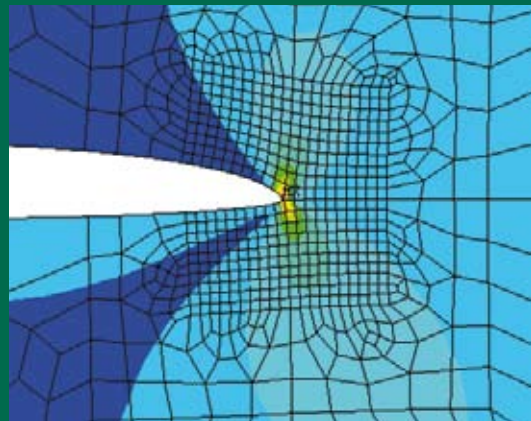


COMPETENCES



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Center for Microtechnologies

The Center for Microtechnologies (ZfM), founded in 1991, belongs to the department of Electrical Engineering and Information Technology of the Chemnitz University of Technology (CUT). It is the basis for education, research and developments in the fields of micro and nanoelectronics, micro mechanics and micro-system technologies in close cooperation with various chairs of different CUT departments.

The ZfM's predecessor was the "Technikum Mikroelektronik" which was established in 1979 as a link between university research and industry. For that reason the Chemnitz University of Technology has a tradition and experience for more than 30 years in the fields of microsystem technology, micro and nanoelectronics, as well as opto-electronics and integrated optics.

The key of success is the interdisciplinary cooperation of different chairs within the ZfM. The board of directors consists of

- Chair Microtechnology - Prof. Gessner
- Chair Microsystems and Precision Engineering - Prof. Mehner
- Chair Circuit and System Design - Prof. Heinkel
- Chair Electronic Devices of Micro and Nano Technique - Prof. Horstmann
- Chair Electrical Measurement and Sensor Technology - Prof. Kanoun
- Chair Power Electronics and Electromagnetic Compatibility - Prof. Lutz
- Chair Materials and Reliability of Microsystems - Prof. Wunderle.



President of the Board
Prof. Dr. Thomas Gessner



Deputy of the President
Dr. Karla Hiller

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Additionally two departments belong to the ZfM, the department Lithography/Etch/Mask as well as the department Layer Deposition. The ZfM facilities include 1000 m² of clean rooms, whereby 300 m² of them belong to clean-room class ISO4. Modern equipment was installed for processing of 4", 6" and 8" wafers.

The ZfM carries out basic research, practical joint projects and direct research & development orders for the industry in the following fields:

- Basic technologies and components for microsystems and nanosystems (sensors, actuators, arrays, back-end of line)
- Design of components and systems
- Nanotechnologies, nano components and ultra-thin functional layers

Within the last years a very strong cooperation has been established with the Fraunhofer Research Institution for Electronic Nano Systems ENAS and the other partners within the Smart Systems Campus Chemnitz.

Please visit our homepage:
<http://www.zfm.tu-chemnitz.de/>

Chair Microtechnology



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Main working fields:

- Development of new materials and processes for metallization systems in micro and nano-electronics
- Simulation and modeling of equipment and processes for micro and nanoelectronics as well as nano materials and nano structures
- Development of nanotechnologies, nano components and ultra-thin functional films
- Development of plasma processes for photovoltaics
- Development of technologies and components for microsystems and nanosystems (sensors, actuators and arrays)
- Processes and technology for integration of electronics and micro as well as nanosystem components
- Prototype fabrication of sensors, actuators and arrays
- Processing services for customer applications

Special attention is paid to Si-based MEMS technologies:

- Bulk technology
- High aspect ratio technologies, e.g. air gap insulated microstructures (AIM technology)
- Encapsulation by wafer bonding
- Encapsulation by thin film technology

Several high aspect ratio MEMS technologies, such as the patented AIM technology or the BDRIE (Bonding and Deep RIE) technology, have been established in order to fabricate high precision inertial sensors, e.g. acceleration, vibration and inclination sensors as well as gyroscopes. For example, low g acceleration sensors fabricated by AIM technology exhibit an outstanding performance regarding noise density ($20 \mu\text{g}/\text{Hz}^{1/2}$) and temperature stability ($< 0.025\%/K$). By involving a two-step anisotropic dry etching in these technology flows, electrode configurations with different height can be realized, Fig. 1. They enable out-of-plane operation modes in addition to the in-plane modes, hereby contributing to three-dimensional motion sensing, which is presently under investigation.

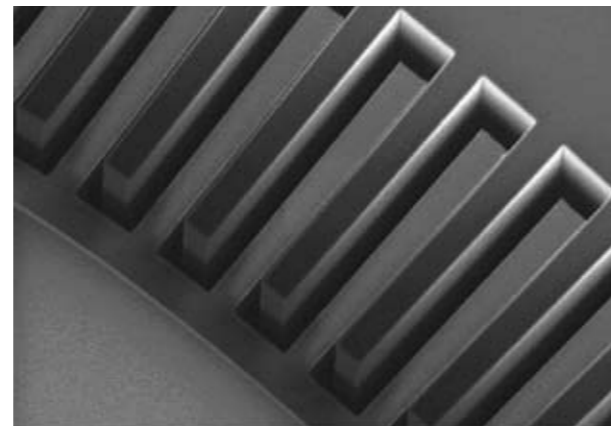


Fig. 1: Comb drive (teeth with different height) for vertical excitation

Besides various wafer bonding methods for zero level packaging of the MEMS, a thin film encapsulation tech-

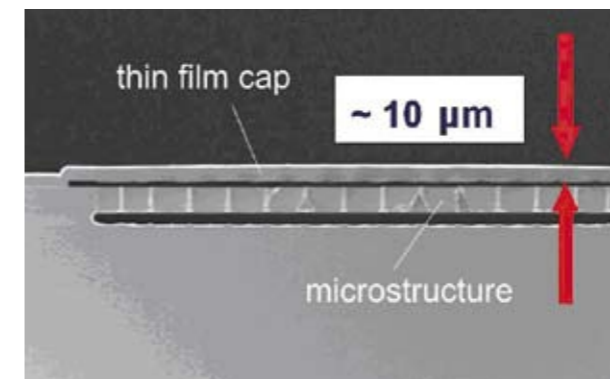


Fig. 2: Thin film cap over a HAR sensor structure

nology has been developed and proven. A thin layer stack of oxide and nitride (and optionally a metal such as Al) is covering and protecting the active part of the HAR sensor, Fig. 2. A CF polymer is used as a sacrificial layer, which exhibits selective dry sacrificial layer etch process with high etch rates (in oxygen plasma). This newly developed thin film cap shrinks the vertical dimension of the cap down to about $10 \mu\text{m}$ and contributes to lateral shrinking too, as no bonding frames are required.

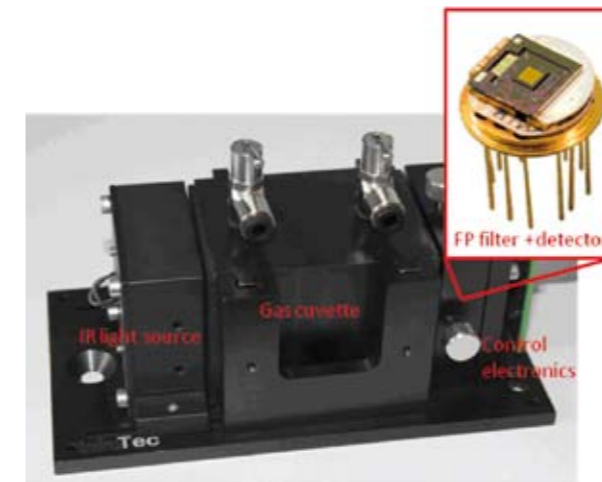


Fig. 3: Microspectrometer demonstrator setup based on MEMS FPI by courtesy of InfraTec GmbH Dresden

Micromachined Fabry-Perot filters for the NIR range ($3 \dots 5 \mu\text{m}$) for spectral analysis of gases have been fabricated for several years, Fig 3. Recently, in joint projects with Fraunhofer ENAS, InfraTec Dresden, Jenoptik LOC and IOM Leipzig, further improvement could be demonstrated, e.g. extension of the measuring range to the $8 \dots 11 \mu\text{m}$ window by integration of new optical

materials. Besides distributed bragg layers, nanostructures are under investigation.

Special attention is paid to thin films ranging from several nanometers to a couple of microns in thickness. They are used as active and functional layers in micro electronic devices, as intermediate layers for packaging processes or protective coatings for micro machines or even as functional films in optical components like gratings or interferometers.

Selected publications:

Reuter, D.; Nowack, M.; Bertz, A.; Wiemer, M.; Semar, R.; Hopp, K.-F.; Dietrich, S.; Thieme, T.; Herbst, K.; Gessner, T.: INTEGRATION OF INERTIAL MEMS SENSORS IN ACTIVE SMART RFID LABELS FOR TRANSPORT MONITORING. Smart Systems Integration 2009, Proceedings, (2009) (ISBN 978-3-89838-616-6).

Neumann, N.; Ebermann, M.; Hiller, K.; Kurth, S.: NOVEL MWIR MICROSPECTROMETER BASED ON A TUNABLE DETECTOR. MOEMS and Miniaturized Systems VIII, San Jose; Proc. of SPIE, 7208 (2009).

Waechter, T.; Oswald, S.; Roth, N.; Jakob, A.; Lang, H.; Ecke, R.; Schulz, S.E.; Gessner, T.; Moskvina, A.; Schulze, S.; Hietschold, M.: COPPER OXIDE FILMS GROWN BY ATOMIC LAYER DEPOSITION FROM BIS(TRI-N-BUTYLPHOSPHANE) COPPER(I)ACETYLACETONATE ON TA, TAN, RU, AND SiO₂.J. Electrochem. Soc., 156 (2009) pp. H453-H459 (ISSN 0013-4651).

Leidich, S.; Braun, M.; Gessner, T.; Riemer, T.: SILICON CYLINDER SPIRAL COIL FOR NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY OF NANOLITER SAMPLES. Concepts in Magnetic Resonance Part B (Magnetic Resonance Engineering), 35B(1) (2009) pp. 11-22.

Hofmann, L.; Ecke, R.; Schulz, S.E.; Gessner, T.: METALLISIERUNGSVERFAHREN FÜR DIE 3D INTEGRATION IN DER MIKROELEKTRONIK UND MIKROSYSTEMTECHNIK. 12. Werkstofftechnisches Kolloquium, Werkstoffe und Werkstofftechnische Anwendungen, Tagungsband, 35 (2009) pp. 120-125 (ISBN 978-3-00-029007-7/1439-1597).

Chair Microsystems and Precision Engineering



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The Chair of Microsystems and Precision Engineering is mainly focused on design and experimental characterization of micro-electro-mechanical systems (MEMS) and their applications. Innovative technologies are investigated in order to link mechanics, optics, electrical engineering and electronics for highly integrated smart systems. Therefore the second focus is on precision engineering.

Main working fields:

- Modeling and simulation of physical domains and their interactions
- Experimental characterization and measurement methodologies
- Sensor and actuator development
- Wireless communication and energy scavenging

Microsystems are key components of complex heterogeneous devices such as automotive products, industrial automation and consumer applications. Academic research and education is strongly related to partners from industry and research institutes (e.g. Fraunhofer Institutes, IPHT Jena, ...).

One of the most advanced topics in the field of design is the challenge to establish fast and precise behavioral models for microsystems. Parametric reduced order modeling (ROM) technique, Fig. 1, is the most promising approach to this. The parametric ROM macromodels capture the complex nonlinear dynamics inherent in MEMS due to highly nonlinear electrostatic forces, residual stresses, stress stiffening and supports multiple electrode systems and mechanical contact phenomena. Geometrical nonlinearities, such as stress stiffening, can be taken into account if the modal stiffness is computed from the second derivatives of the strain energy with respect to modal coordinates. The ROM technique based on the mode superposition method is a very efficient technique for fast transient simulation of MEMS components in order to export macromodels for external system simulators.

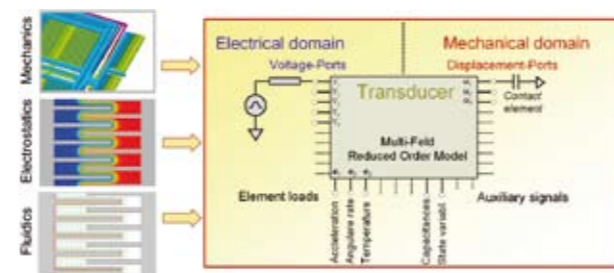


Fig. 1: Reduced order modeling for microsystems design

This advanced design technique is successfully used for instance for the design of the vibrational sensor shown in Fig. 2.

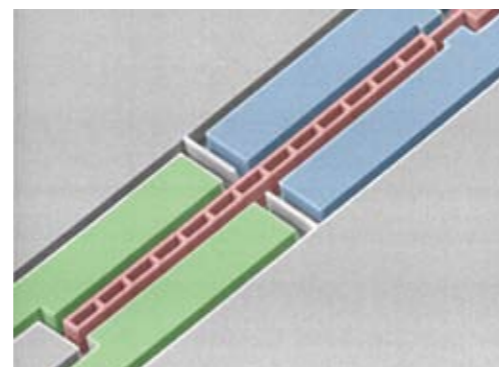


Fig. 2: Zoomed and colored view of a vibration sensor for machine noise detection

The Chair of Microsystems and Precision Engineering has a state of the art measurement lab for characterization. It is equipped with an atomic force microscope (AFM), autofocus topography, dynamics measurement system and different types of interferometrical measurement systems. Fig. 3 shows the currently most advanced tool which is a PVM-200 Vacuum Wafer Prober equipped with a Micro System Analyzer MSA 500 enabling dynamic and topographic characterization of MEMS at adjustable vacuum and thermal interference. The MSA uses laser doppler vibrometry with scanning laser beam and stroboscopic illumination for out-of-plane and in-plane motion analysis respectively. White light interferometry allows topographic measurements in vacuum conditions.



Fig. 3: PVM-200 vacuum wafer prober and microsystem analyzer

One of the currently running projects is related to a pressure measurement catheter for the human esophagus with high resolution regarding pressure and position. Fig. 4 shows the working principle of a chirped FBG sensing system. A wideband light source is selectively reflected by FBGs of chirped reflection wavelength. In case of the presented pressure sensor catheter the FBGs are sensitive to pressure and the characteristic wavelengths can be allocated to the place of applied pressure. The advantages are the absence of electrical components, the feasibility of long time measurements, the non-bulky interrogation systems which allow the manometry in rather natural situations and the homogeneous surface which enables easy cleaning and disinfection.

Other current research projects:

- Development of a parametric ROM technique for precise and fast simulation of microsystems
- Design and characterization of microsystems for acoustic emission and vibration detection

- Development of test structures based characterization technique for the extraction of critical technological parameters for microsystems on wafer level
- Development of vibrational energy harvester
- Development of a friction vacuum gauge with an extended measurement range

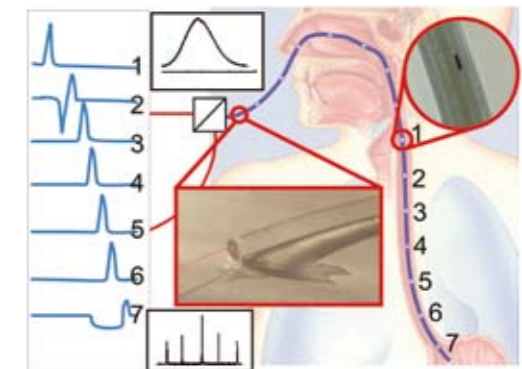


Fig. 4: Working principle of a medical pressure sensor catheter for esophageal diagnosis

Selected Publications:

Mehner, J.; Kolchuzhin, V.; Schmadlak, I.; Hauck, T.; Li, G.; Lin, D.; Miller, T. F.: THE INFLUENCE OF PACKAGING TECHNOLOGIES ON THE PERFORMANCE OF INERTIAL MEMS SENSORS. Proceedings of 15. Intern. Conf. on Solid State Sensors, Actuators and Microsystems, Transducers' 09, (2009) pp. 1885-1888.

Shaporin, A.; Streit, P.; Specht, H.; Dötzel, W.; Mehner, J.: NOVEL TEST-STRUCTURES FOR CHARACTERIZATION OF MICROSYSTEMS PARAMETERS AT WAFER LEVEL. SPIE – Photonics West, Proc. SPIE 7206 (2009) pp. 72060E-1-12.

Naumann, M.; Koury, D.; Lin, D.; Oi, H.; Miller, T.F.; Mehner, J.: CHARACTERISATION OF STICKING EFFECTS BY SURFACE MICRO-MACHINED TEST STRUCTURES. Chemnitzer Fachtagung Mikrosystemtechnik, Tagungsband, (2009). S. 103-107

Forke, R.; Scheibner, D.; Dötzel, W.; Mehner, J.: MEASUREMENT UNIT FOR TUNABLE LOW FREQUENCY VIBRATION DETECTION WITH MEMS FORCE COUPLED OSCILLATORS. Sensors and Actuators A: Physical, 156, 1 (2009) pp. 59-65 (ISSN 0924-4247).

Kolchuzhin, V.; Forke, R.; Dötzel, W.; Mehner, J.: HIGH ORDER DERIVATIVES TECHNOLOGY IN ADVANCED MEMS MODELING. Smart Systems Integration 2009, Proceedings (2009) pp. 472-475 (ISBN 978-3-89838-616-6).

Chair Circuit and System Design



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Main working fields:

- Design of ASICs (Application Specific Integrated Circuits) and FPGAs (Field Programmable Gate Arrays)
- Design of heterogeneous systems (MEMS) in cooperation with the Chairs of the Center for Microtechnologies
- Formal specification/verification methodologies for digital, analogue and heterogeneous systems with VHDL, VHDL-AMS, SystemC, SystemC-AMS, SystemVerilog
- Efficient communication (Car2X, application of wireless networks ad-hoc networks, network management, bandwidth reduction with digital image processing, localization algorithms)

During many years of work in the area of circuit and system design, a huge knowledge in application specific integrated circuits (ASIC) design has been accumulated. Special know-how and experience exist in the field of PLD and FPGA (field programmable gate arrays) design and application.

Many different systems have been designed, e.g. systems for real time processing, rapid prototyping systems for image processing, vibration pattern recognition systems and coupling of simulators and emulators. Research areas include:

- System design of heterogeneous microsystems in cooperation with the Chair of Microsystems and Precision Engineering and the Center of Microtechnologies
- Research work in logic and system design and application of FPGAs and PLDs
- High performance arithmetic for different special purposes (e.g. MPEG video decoders, image compression, graphic controllers)
- Design of re-usable components and IP (Intellectual Properties), development of design environments for re-usable components and applications
- Specification capturing, formal specification with interface-based design methods
- Utilization of fuzzy accelerators for recognition of vibration patterns and classification (noise analysis)
- Development and application of a modular system (including graphical user interface) for real time functions (inspection of textile surfaces, analysis of skin diseases, real time image processing, fuzzy classification systems, controlling of projection systems)
- Design and evaluation of high performance data path components
- Low power design (system bus encoding techniques for reduced power dissipation)

Although many projects have been processed through the years, there is still a lot of work ahead.



Fig. 1: Daniel Kriesten, presenting a prototype of an on-board unit, developed within the project "Generalisierte Plattform zur Sensordaten-Verarbeitung GPSV"

Recently, the chair has 28 employees, most of them working on application specific industrial research projects. Some of those projects, for example, are:

- BMBF-project Innoprofile „Generalisierte Plattform zur Sensordaten-Verarbeitung GPSV“
- EU-project MORPHEUS: Multipurpose Dynamically Reconfigurable Platform for Intensive and Flexible Heterogenous Processing
- Joint project (BMBF): Kompetenznetzwerk für Nanosystemintegration: Teilvorhaben: NEMS/MEMS-Elektronik-Integration für energieeffiziente Sensorknoten
- BMBF-project Netz der Zukunft – MxMobile „Multi-Standard Mobile Platform“ (Teilvorhaben: Kostenmodellierung zur verbesserten Design Space Exploration)
- BMBF-project „Mx Mobile: Multi-Standard Mobile Platform“, Phase 1
- BMBF-project Herkules „Hardwareentwurfstechnik für Null-Fehler-Designs“
- BMBF-project ForMaT2: Faserkunststoffverbunde mit integrierter Zustandsüberwachung in Echtzeit (FIZ-E)
- Joint project (DLR): SEIS: Teilvorhaben: Entwurf und Bewertung eingebetteter IP-basierter NetzeProject (Industry)

- Paraobsol: Entwicklung einer Anwendung zur Erfassung und Bearbeitung von Spezifikationsdaten

Selected Publications:

Shende, M.; Roßberg, C.; Markert, E.; Herrmann, G.; Heinkel, U.: MODELING AND SIMULATION OF A MICRO-GYROSCOPE USING MATLAB/SIMULINK AND VHDL-AMS. 9. Chemnitz Fachtagung Mikrosystemtechnik - Mikromechanik & Mikroelektronik, Tagungsband (2009) S. 108-114 (ISBN 978-3-00-029135-7).

Rößler, M.; Wang, H.; Heinkel, U.; Engin, N.; Drescher, W.: RAPID PROTOTYPING OF A DVB-SH TURBO DECODER USING HIGH-LEVEL-SYNTHESIS. Forum on Specification & Design Languages, Sophia Antipolis, France, (2009).

Masoumi, M.; Markert, E.; Heinkel, U.; Gielen, G.: ULTRA LOW POWER FLASH ADC FOR UWB TRANSCEIVER APPLICATIONS. European Conference on Circuit Theory and Design EECTD, Antalya, Turkey, (2009) (ISBN of CD: 978-1-4244-3896-9).

Markert, E.; Goller, S.; Pross, U.; Schneider, A.; Knäblein, J.; Heinkel, U.: ETHERNET BASED IN-SERVICE RECONFIGURATION OF SoCs IN TELECOMMUNICATION NETWORKS. in: Voros, N.; Rosti, A.; Hübner, M. (Eds.): Dynamic System Reconfiguration in Heterogeneous Platforms – The MORPHEUS Approach. Springer Verlag, (2009) pp. 195-203 (ISBN 978-90-481-2427-5).

Froß A.; Froß D.; Heinkel, U.: COMMUNICATION NETWORK WITH SELF-SUFFICIENT AND SUB-METER LOCALIZATION CAPABILITIES. Smart Systems Integration 2009, Proceedings, (2009) pp. 456-459 (ISBN 978-3-89838-616-6).

Markert, E.; Pross, U.; Richter, A.; Heinkel, U.: A SPECIFICATION ENVIRONMENT FOR MEMS. Smart Systems Integration 2009, Proceedings, (2009) pp. 484-487 (ISBN 978-3-89838-616-6).

Roßberg, C.; Markert, E.; Herrmann, G.; Heinkel, U.: MODELLIERUNG UND SIMULATION EINES GYROSKOPES. Workshop "Simulation technischer Systeme Grundlagen und Methoden in Modellbildung und Simulation", Proceedings, (2009) (ISBN 978-3-8167-7981-0).

Chair Electronic Devices of Micro and Nano Technique



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Main working fields:

- Sub-50nm-MOS-transistors modeling
- Modeling and simulation of electronic devices for microsystem electronics
- Sensor signal evaluation and actuator control of microsystems
- Matching behavior analysis of nano-sized CMOS transistors
- Manufacturing, analysis and characterization of next-generation nanoelectronic devices
- Integrated circuit design for microsystem electronics, especially low noise, low power and high voltage

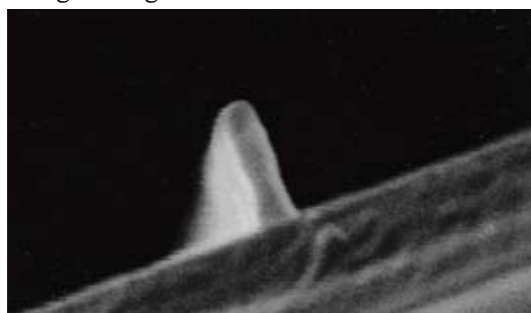


Fig. 1: SEM-picture of a gate electrode of a sub-50nm-MOS-transistor

- Layout and verification of analog and mixed signal circuit designs for microsystem technology

The main research topics at the Chair of Electronic Devices of Mico and Nano technique are:

- Investigation and evaluation of the trench isolations and characterization of the electrical parameters
- Development of strategies to reduce the statistical parameter fluctuations of very small MOS-transistors
- Simulation and characterization of sub-50nm-MOS-transistors
- Analysis of the physical mechanisms of micro and nanoelectronic devices
- Development of measurement methods for the analysis of the electrical parameters of next generation nano electronic devices
- New circuit concepts for nanoelectronic mechanical systems
- Invention of new materials in the CMOS-process for next generation nano devices.
- Evaluation of In-Die parameter variations, planning of experiments to reduce parameter deviations and assistance for suitable teststructures creation.

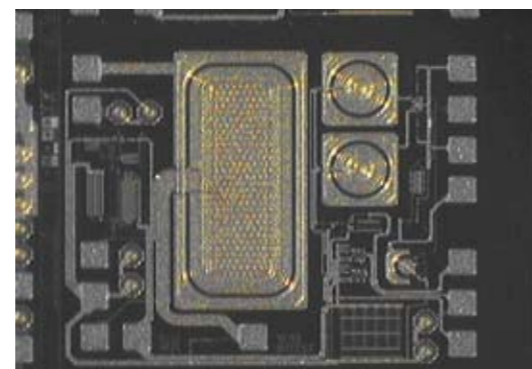


Fig. 2: Example for an electronic microsystem

Main areas of responsibility in the research activities of the "Microsystem Electronics" working group at the Chair of Electronic Devices of Micro and Nano Technique are the development of integrated electronic microsystems and electronic micro and nano devices and the solution of customer-oriented problems.

The current research projects are:

- Smart-power applications realized by a trench isolation, which contains the design of integrated high-voltage electronics and characterization from high voltage isolation structures to optimize the production technology
- Design of intellectual properties for the MEMS-technologies, currently for a $1\mu\text{m}$ -CMOS-technology with monolithic integrated pressure sensors
- Development of modern electrical drive systems like electric motors with high efficiency and smart-power-control-concepts
- Development of customized measuring strategies and characterization of In-Die parameter variations for semiconductor structures in nano technologies
- Electrical and physical design of analog and mixed signal standard circuits for the CMOS-process
- Creation of simulation models for SOI-devices
- Investigation and modeling of isolation structures for high-voltage-ICs

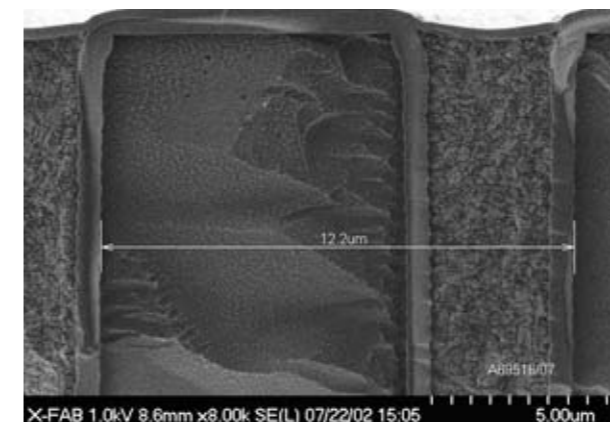


Fig. 3: SEM Picture of a complete trench [X-FAB]

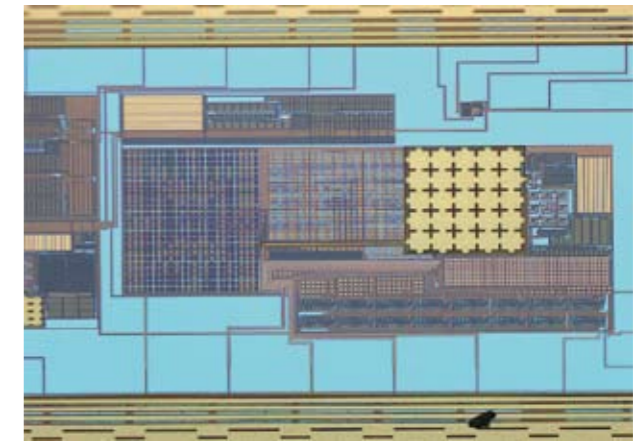


Fig. 4: Layout of an electronic micro device

Example for an integrated smart-power application:

Electrostatic driven micromechanical components with capacitive behavior referring to their terminals include micro mirrors rotating in one or two dimensions and transducers based on the piezoelectric effect. Front-end circuits which are used to control such microelements for various applications have to be smart power amplifiers with the ability to drive up to 1000 V. Various examples of such circuits have been demonstrated over the last years.

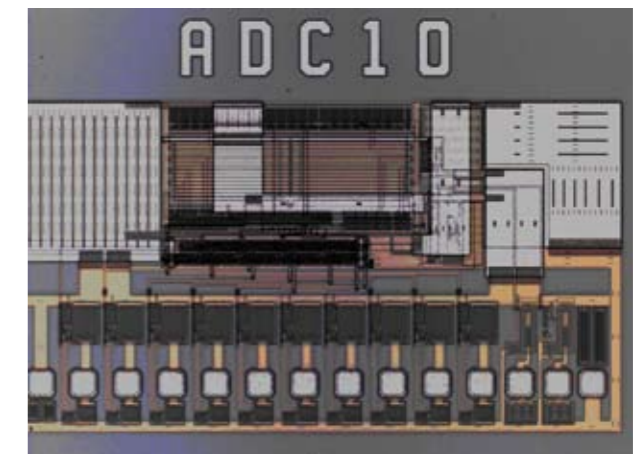


Fig. 5: 10 Bit analog-to-digital-converter

Selected publications:

Kallis, K. T.; Horstmann, J. T.; Küchenmeister, C.; Keller, L. O.; Fiedler, H. L.: COST-EFFECTIVE MOSFET-TRANSISTORS ON BULK SILICON IN THE DEEP SUB-50 NM-REGION. 6th International Multi-Conference on Systems, Signals and Devices, SSD'09, 2009, Proceedings: IEEE Press (ISBN 978-9973-959-16-8).

Chair Electrical Measurements and Sensor Technology



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Main research focus:

- Impedance spectroscopy for measurement systems and sensors
- Energy harvesting and energy autonomous systems
- Sensors based on carbon nanotubes (CNT)

Smart sensor systems provide promising technical solutions which can significantly contribute to an improvement of quality, reliability and economic efficiency of technical systems.

The research activities at the chair for measurement and sensor technology (MST) have a strategic focus on the improvement of measurement and sensor principles, the design of smart sensor systems and the model-based signal processing. The MST-Team is organized in three research groups focusing on impedance spectroscopy, energy harvesting and sensors based on carbon nanotubes.

Impedance Spectroscopy is a powerful measurement method used in many application fields such as electrochemistry, material science, biology and medicine, semiconductor industry and sensors. The possibility to use

information in the complex impedance over a wide frequency range leads to interesting opportunities for separating effects, more accurate measurements and measurements of inaccessible quantities. The experience of the chair for measurement and sensor technology in this field includes several methodological contributions involving the main aspects of measurement techniques, physical-chemical modeling and signal processing. Running research projects deal with diagnosis of Li-Ion batteries, material measurements and sensors, Fig. 1.

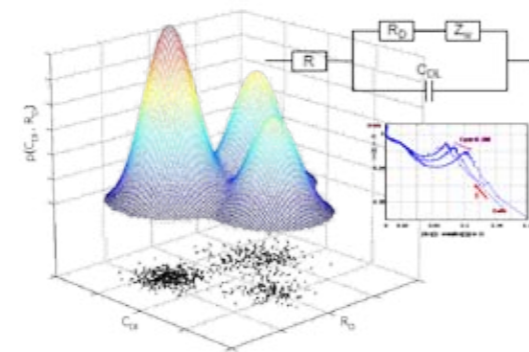


Fig. 1: Parameter extraction for diagnosis of Li-ion cell

Energy harvesting is the use of ambient energy to power small electronic devices, making them self-sufficient. It allows the realization of autonomous systems having reduced installation and maintenance costs. A variety of energy conversion principles and technologies can be nowadays adopted to convert temperature differences, vibration or electrostatic energy, Fig. 2. In order

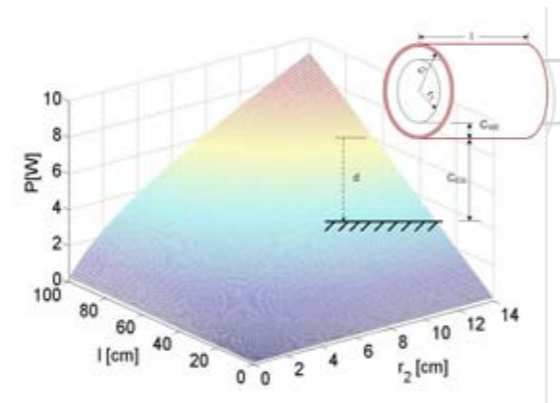


Fig. 2: Energy harvesting from the electrostatic field of a high-voltage power line

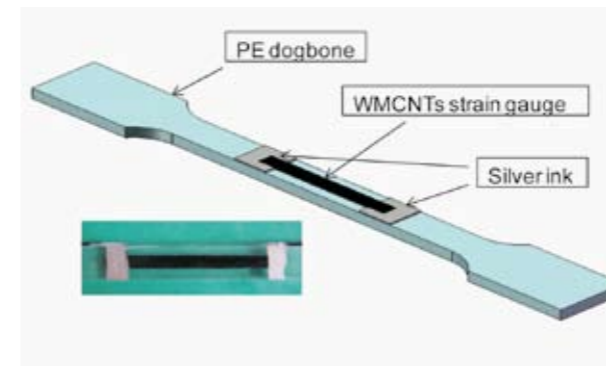


Fig. 3: Strain gauges based on CNT films

to bridge low energy availability, system should be capable to accumulate superfluous energy and to manage energy flows between converter, storage unit and application. Investigations of components and their interaction are of a big importance for the design of systems using ambient energy. The limited efficiency of energy converter, the heavy fluctuations of energy availability changing environmental conditions and the limited capacity of storage units are challenging aspects for the system design. For this purpose, a test platform has been developed, to characterize energy harvesting systems at component and system level. Sophisticated energy management concepts have been developed considering high fluctuations of energy availability.

The technological progress in the field of micro and nano technology allows promising possibilities for new sensors and sensor principles, which will play a key role in future. Novel sensors with outstanding performance can be realized using multi walled and single walled CNTs in different technologies and allowing the measurement of versatile measurement quantities. Different activities are in progress aiming to demonstrate the benefits of CNTs for sensors particularly for mechanical and optical measurement quantities. For example, CNT thin films have been realized for use as strain gauges, Fig. 3. They can be manufactured in different forms, have a high sensitivity and a big measurement range and are self adhesive.

Current research projects focus on:

- Battery diagnosis (state of charge, state of health, state of function)
- Material testing by impedance spectroscopy
- Meat quality monitoring by impedance spectroscopy
- Cable testing methods

- Soil moisture measurement independent on soil type
- Availability and conversion of ambient energy
- Experimental evaluation of thermo electrical converter
- Design of energy autonomous systems
- Energy conversion from electrostatic field
- Smart energy management
- Strain gauges based on Carbon Nanotubes
- Temperature measurement using p-n junctions

Selected Publications:

Kanoun, O.: FUTURE PROSPECTS FOR SMART SENSOR SYSTEMS. Sixth International IEEE Multi-Conference on Systems, Signals and Devices SSD'09, Proceedings (2009).

Dinh, N.; Steitz, J.; Bu, L.; Kanoun, O.: INFLUENCE OF THE COMPOSITION OF MWCNTs LAYERS ON THE PROPERTIES OF STRAIN GAUGES. 2009 9th IEEE Conference on Nanotechnology, Proceedings, (2009) S. 576 - 579.

Bu, L.; Steitz, J.; Dinh, N.; Kanoun, O.: INFLUENCE OF PROCESSING PARAMETERS ON ELECTRICAL PROPERTIES OF CARBON NANOTUBE FILMS. 2009 9th IEEE Conference on Nanotechnology, Proceedings, (2009) S. 401 - 404.

Keutel, T.; Zhao, X.; Kanoun, O.: ENERGY SCAVENGING FOR OVERHEAD POWER LINE MONITORING SYSTEM. SENSOR+TEST Kongress Nürnberg (2009).

Cuadras, A.; Kanoun, O.: SoC LI-ION BATTERY MONITORING WITH IMPEDANCE SPECTROSCOPY. Sixth International IEEE Multi-Conference on Systems, Signals and Devices SSD'09, Proceedings, (2009).

Tröltzsch, U.; Kanoun, O.: MINIATURIZED IMPEDANCE MEASUREMENT SYSTEM FOR BATTERY DIAGNOSIS. SENSOR+TEST Kongress Nürnberg, (2009).

Kanoun, O.: PROSPECTS AND CHALLENGES OF IMPEDANCE SPECTROSCOPY. International Workshop on Impedance Spectroscopy, Chemnitz (2009).

Chair Power Electronics and Electromagnetic Compatibility



Contact: Prof. Dr. Josef Lutz

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The education covers power devices, thermo-mechanical problems of power electronic systems, power circuits and electromagnetic compatibility. The focus of research is on power devices, especially their reliability. The main fields of research are:

- Reverse recovery of high power diodes, dynamic avalanche and ruggedness: At high stress conditions in dynamic avalanche, current tubes or filaments occur. Of most importance

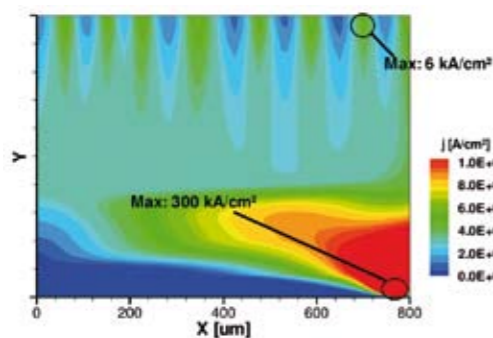


Fig. 1: Simulation of current filaments in a 6.5-kV power diode at strong dynamic avalanche. Eight filaments have formed on the anode side, one filament with extreme current density at the cathode side. Point in time short before electro-thermal runaway. Short circuit III test with a 1.2 kA 2.5 kV IGBT module. Measurement GE Global Research Europe. Power cycling: Measured junction temperature T_j and case temperature T_{case}

is the nn+-junction. Designs with improved ruggedness are deduced.

- Surge current capability of power diodes in Si and SiC: Metallization thickness and interconnection pitch are of decisive influence.
- Short circuit capability of high voltage IGBTs: Power devices must be capable to withstand extreme high loads at fault conditions. Fig. 2 shows the waveform of a short circuit type III - external short circuit while a freewheeling diode is conducting.

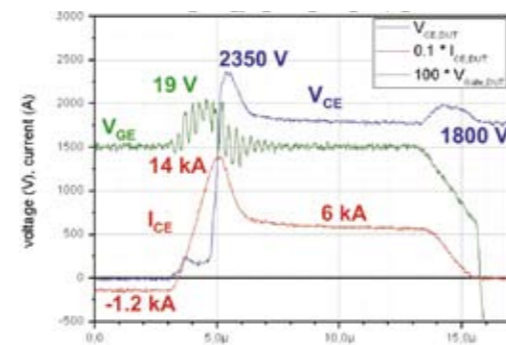


Fig. 2: Simulated mechanical deformation of a power device and substrate at power cycling, z-axis 1000x extended.

- Long term blocking stability of power devices: A hot reverse test station, DC 2500V, T_j up to 200 °C, has been built and is running
- Reliability of packaging technologies: The focus is on power cycling. Seven self-build power cycling stations are running. New interconnec-

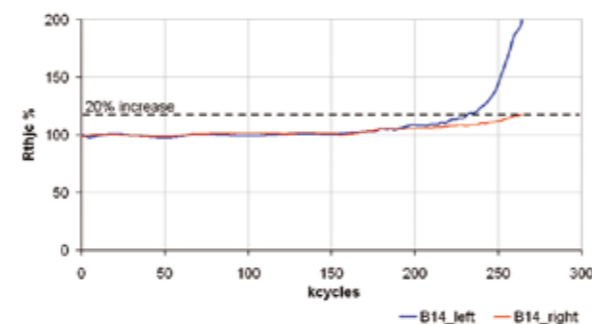


Fig. 3: Power cycling result of a 1200-V power module for automotive applications. Shown is the thermal resistance R_{thjc} depending on the No. of cycles. An increase by 20% is rated as failure.

tion technologies for power cycling capability up to 200 °C are investigated.

- Simulation of thermal-mechanical stress in power devices: The analysis shows the local mechanical stresses and strains in the package, which result from the mismatch in the thermal expansion of the material layers, Fig. 4.

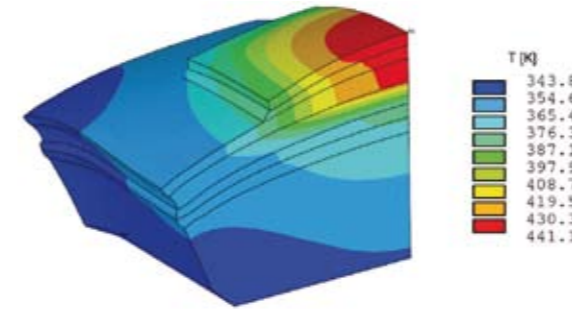


Fig. 4: Simulated temperature and mechanical deformation of a power chip and package layers at power cycling. Deformation scale factor 1000. Dissipated power 236 W/cm² water cooling, coolant temperature 313K. ¼ chip and surrounding layers simulated.

- Failure analysis: Electrical measurements, opening of power modules, inspection, if necessary REM analysis etc, failure reports including evaluation.



Fig. 5: Partial integration of the power electronic system in the automobile gear unit (EFA-project)

Important research projects:

- Electric components for active gears – EFA, joint project 2006-2010 for increased energy density of the electric components in the power train of a hybrid vehicle

- Short circuit in high-voltage IGBTs, joint project with GE Global Research Europe, measurement and analysis of short circuit events. Project finished March 2009

- High power converters for offshore applications, joint project with NTNU Trondheim and SINTEF Norway, project started in December 2009, our task is the analysis of fault mechanisms and design measures to increase reliability and ruggedness of high power converters for future large offshore wind parks

- Electric components for active gears - EFA, joint project 2006-2010 for increased energy density of the electric components in the power train of a hybrid vehicle

- Advanced Supercaps on base of nano-structured materials - Nanocap, joint project finished in 2008. New materials for electrodes and electrolytes for a new generation of double-layer capacitors have been developed and their reliability was investigated

Selected publications:

Lutz, J.; R. Baburske, R.; Chen, M.; Heinze, B.; Felsl, H.-P.; Schulze, H.-J.: THE NN+-JUNCTION AS THE KEY TO IMPROVED RUGGEDNESS AND SOFT RECOVERY OF POWER DIODES. IEEE Trans El Dev, 56,11 (2009).

Baburske, R.; Heinze, B.; Niedernostheide, F.-J.; Lutz, J.; Silber, D.: ON THE FORMATION OF STATIONARY DESTRUCTIVE CATHODE-SIDE LAMENTS IN P+-N-N+ DIODES. in Proc. ISPSD, (2009) pp. 41–44.

Lutz J.; Döbler, R.; Mari, J.; Menzel, M.: SHORT CIRCUIT III IN HIGH POWER IGBTs. Proceedings EPE (2009).

Baburske, R.; Domes, D.; Lutz, J.; Hofmann, W.: PASSIVE TURN-ON PROCESS OF IGBTs IN MATRIX CONVERTER APPLICATIONS. Proceedings EPE (2009).

Poller, T.; Feller, M.; Hoyer, I.; Lutz, J.: THERMAL - MECHANICAL BEHAVIOUR OF SOLDER LAYERS IN POWER MODULES. PCIM Europe 2009, Nuremberg, (2009).

Lutz, J.: IGBT-MODULES: DESIGN FOR RELIABILITY. Invited paper, Proceedings EPE (2009).

Chair Materials and Reliability of Microsystems



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The chair „Materials and Reliability of Microsystems” has been held by Bernhard Wunderle since July 2009. Many of the research and lecturing activities are therefore still being built up.

Lectures:

The professorship is responsible for the scientific education in the field of material science for students of electrical engineering and microelectronics and focuses on the reliability assessment and prediction for micro and nano-systems for graduate students, including the new international master's program in micro and nano systems.

Research:

Reliability as a scientific discipline is concerned with the analysis, assessment and prediction of the lifetime of microelectronic systems (e.g. of interconnects and interfaces of standard and advanced packages, BEOL-layers, MEMS, 3D-architectures, SIP, etc).

The main challenges involved therein are the handling of the complexity of microsystems (system-reliability), the correlation of degradation to the nanostructure of the materials (nano-reliability) and the generation of

lifetime models for the transferability between field and lab testing conditions (definition of accelerated and combined tests).

Reliability prediction crucially hinges upon the correct and accurate description of the respective failure mechanisms. The research therefore comprises the development of lifetime models for microsystems starting from the material level up to the system level, based on the physical understanding of the materials involved in terms of their properties and failure mechanisms as function of their structure and external loading conditions (“physics of failure”).

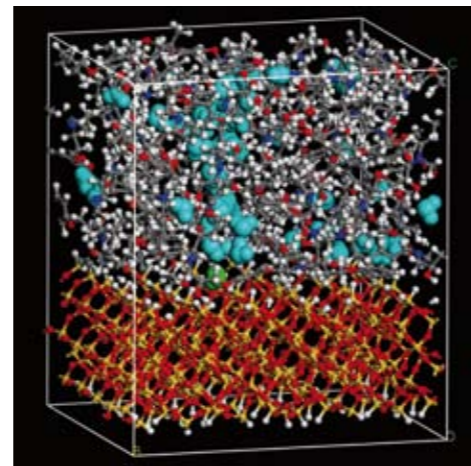


Fig. 1: Molecular dynamics simulation of cross-linked epoxy resin on SiO_2 with H_2O molecules to study moisture diffusion and adhesive properties under different temperature and pressure boundary conditions to obtain structure-property correlations

The following fields of competence are being built up in a close collaboration with the Fraunhofer ENAS and Fraunhofer IZM:

Material characterization:

- Thermal and mechanical characterization of materials and compounds of microsystems under typical, application-relevant loading conditions such as temperature, moisture and vibration

- Characterization of cracks in materials and interfaces by means of fracture-mechanical methods considering also process influences on the materials

Simulation:

- Calculation of failure parameters as a function of external loading conditions
- Multi-physics approaches to couple e.g. thermal, mechanical and fluidic fields (Finite Element simulations, Computational Fluid Dynamics) for system simulation
- Multi-scale approaches (e.g. Molecular Dynamics simulation) to obtain structure-property correlations between the nano-scale and the continuum

Experimental analytics:

- Modern non-contact deformation analysis to verify simulation results on various length scales, in this vein degradation and cracks can be observed in-situ in the micro and nano domain (e.g. nm-resolution by microDAC in combination with REM, AFM or FIB)
- Mechanical testing, reliability testing and crack tracing (e.g. by pulse IR thermography) on specimens of small geometry under combined loading conditions

Prof. Wunderle is a member of the European Centre for Micro and Nano Reliability (EUCEMAN) and participates in a joint initiative with Fraunhofer ENAS and

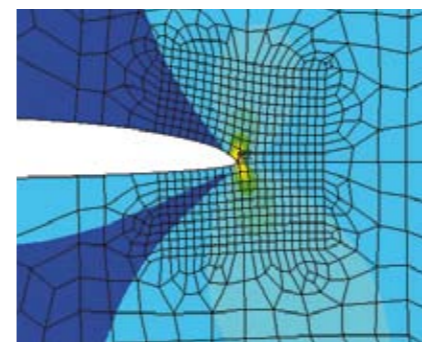


Fig. 2: Finite Element simulation of (asymmetric) crack tip: Stress field to investigate mixed mode crack growth at the interface between silica-filled epoxy resin and a copper surface.

industrial partners to establish a keylab for microreliability in Chemnitz.

Current Projects:

- EU IP Nanopack: Advanced thermal technologies, materials and characterization methods
- EU STREP Nanointerface: Multiscale approach to interface reliability for electronic packages
- BMBF Nanett: Network of competence for nanotechnologies in sensor systems

Selected Publications:

Wunderle, B.; Michel, B.: LIFETIME MODELING FOR MICROSYSTEMS INTEGRATION – FROM NANO TO SYSTEMS. *J. of Microsystem Technologies*, 15, 6 (2009) pp. 799-813.

Wunderle, B.; Dermitzaki, E.; Hölck, O.; Bauer, J.; Walter H.; Shaik, Q.; Rätzke, K.; Faupel, F.; Michel, B.; Reichl, H.: MOLECULAR DYNAMICS APPROACH TO STRUCTURE-PROPERTY CORRELATION IN EPOXY RESINS FOR THERMO-MECHANICAL LIFETIME MODELLING. *Proc. 59th ECTC*, (2009).

Wunderle, B.; Kallmayer, C.; Walter, H.; Braun, T.; Gollhardt, A.; Michel, B.; Reichl, H.: FAILURE MODELING FOR ACA-GLUED FLIP-CHIP ON FLEX ASSEMBLIES. *J. of Microsystem Technologies*, 15, 1 (2008) pp. 3-15.

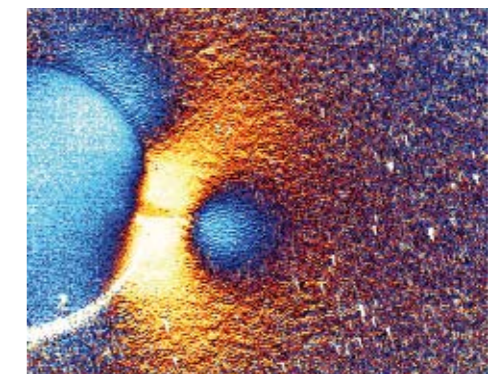


Fig. 3: IR phase image of a mK-temperature field generated during subcritical periodic loading of a crack in PMMA allowing e.g. precise determination of the crack tip position

Honorary Professor for Nanoelectronics Technologies



Contact: Prof. Dr. Stefan E. Schulz

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The development of nanoelectronics is characterized by further shrinking of CMOS technology (More Moore), but also by implementing nanoscale materials and functional films or by completely new approaches (Beyond CMOS). Selected topics within that wide-spread field are treated in the R&D group of this professorship, which is collaborating in the Center for Microtechnologies.

Main working fields:

- Process development for advanced on-chip interconnect systems
- Atomic layer deposition of metal and metal oxide films
- Development of high stress thin films for carrier mobility enhancement in MOS transistors
- Simulation and modeling of stress fields in MOS transistor structures and impact on transistor performance
- Carbon nanotubes (CNTs) for interconnect application: deposition, characterization and integration
- Metallization processes for integration of electronic and micro/nanosystem components

Synergies with micro and nanosystems technology arise from materials also usable for sensoric functions (e.g. CNTs) and thin film deposition for device fabrication (e.g. metallization, ALD films).

Selected publications:

Ahner, N.; Schaller, M.; Bartsch, C.; Baryschpolec, E.; Schulz, S.E.: SURFACE ENERGY AND WETTING BEHAVIOUR OF PLASMA ETCHED POROUS SiCOH SURFACES AND PLASMA ETCH RESIDUE CLEANING SOLUTIONS. *Solid State Phenomena*, 145-146 (2009) pp. 319-322.

Bonitz, J.; Hermann, S.; Loschek, S.; Liu, P.; Schulz, S.E.: SELECTIVE DEPOSITION OF ALIGNED CARBON NANOTUBES FOR NEMS APPLICATIONS. *GMM-Workshop "Mikro-Nano-Integration"*, Seeheim, (2009) (ISBN 978-3-8007-3155-8).

Hermann, S.; Pahl, B.; Ecke, R.; Waechtler, T.; Schulz, S.E.: CARBON NANOTUBES FOR LOW TEMPERATURE FLIP CHIP CONNECTIONS. *Tenth International Conference on the Science and Application of Nanotubes - NT09*, Peking (2009).

Waechtler, T.; Roth, N.; Mothes, R.; Schulze, S.; Schulz, S.E.; Gessner, T.; Lang, H.; Hietschold, M.: COPPER OXIDE ALD FROM A Cu(I) BETA-DIKETONATE: DETAILED GROWTH STUDIES ON SiO₂ AND TAN. *ECS Trans.* 25 (2009) pp. 277-287 (ISSN 1938-5862).

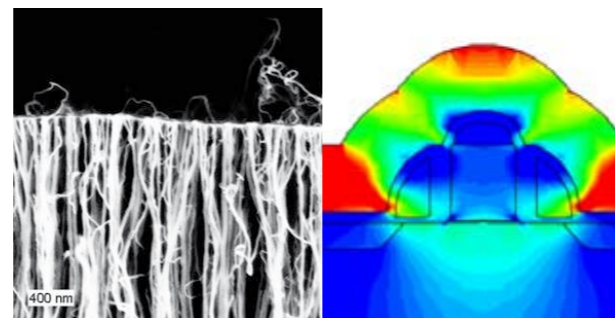


Fig. 1: Vertically aligned carbon nanotubes grown by CVD

Fig. 2: Stress σ_{xx} , nFET, tensile 2 GPa

Honorary Professor for Opto Electronic Systems



Contact: Prof. Dr. Thomas Otto

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Main technology fields:

- Development of micro opto electro mechanical systems MOEMS
- Development of polymer based (functional polymers, nano composites) technologies and components for sensors and actuators
- Development of polymer based micro fluidic systems for different Lab-on-Chip systems
- Prototype service of components and systems

Exemplary for the activities in the field of microoptics is the development and validation of infrared MEMS spectrometers. Such a miniaturized spectrometer has been developed together with the Company Colour Control Farbmesstechnik GmbH Chemnitz. The systems can be configured for different wavelength bands and hence used in various applications. To the fields of application of this spectrometer belong, for example, food studies, environmental monitoring, medical diagnostics, metrology or the physical forensic analysis.

Nanocomposite materials offer certain advantages over classical inorganic materials such as easy processing and nearly unlimited design of components. Additionally typi-

cal included nanoeffects (e. g. quantum confinement) enhance the system performance substantially or provide completely new functionalities. But a big challenge is to bring nanoparticles, nanorods or nanowires in contact to the micro and macro world. To overcome these difficulties we favour different approaches such as use of special conditioned composites (interfaces, orientation of inclusions) or self-assembling technologies.

In current projects humidity and magnetic positioning sensors are being developed by means of nanocomposites. First results look very promising and it seems that the big advantage of composites, namely the separate conditioning of inorganic (nano) inclusions and the organic matrix, lead to cost efficient sensitive sensors with simultaneously high reliability and sensor lifetime.

For all microsystems appropriate electronics for data processing and control, respectively, is developed and manufactured. Thereby the key features of the electronics are, among others, noise reduction and energy efficiency.

Selected publications:

Otto, T.; Saupe, R.; Weiss, A.; Stock, V.; Throl, O.; Graehler, W.; Kaskel, S.; Schreck, H.; Gessner, T.: MEMS Analyzer for fast determination of mixed gases. *MEMS/MOEMS Conference, San Jose, Proceedings of SPIE* (2009).

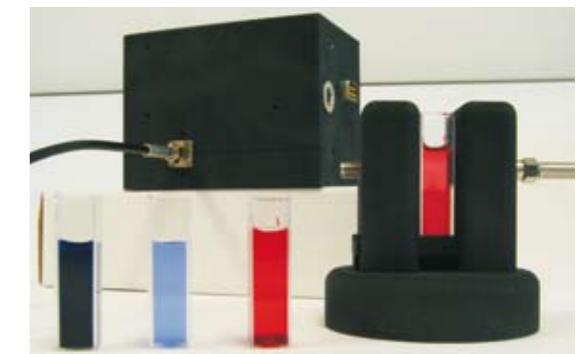


Fig. 1: Spectrometer based on micro mirrors developed at Center for Microtechnologies

Equipment and Service Offers



Fig. 1: View into the new clean room facilities, equipment for depositing foto resist

The ZfM facilities include 1000 m² of clean rooms (300 m² of them class ISO4). Modern equipments were installed for processing of 4", 6" and 8" wafers as well as design and testing laboratories providing the basis for the following processes:

DESIGN

- MEMS/NEMS,
- IC, ASICs and FPGAs
 - » low power and low noise, analogue-mixed signal integrated circuits
 - » integrated high-voltage circuits
- Design support
- Optimization by means of novel approaches, methodologies and dedicated design tools
- Design for reliability

MODELLING AND SIMULATION

- Equipment and processes for micro and nano-electronics
- Physical domains and their interaction
- Thermal simulation
- Electronic devices
- Defects and their influence

MASK FABRICATION

- 3" ... 7" mask size
- Electron beam lithography
- Proximity and contact double-side lithography

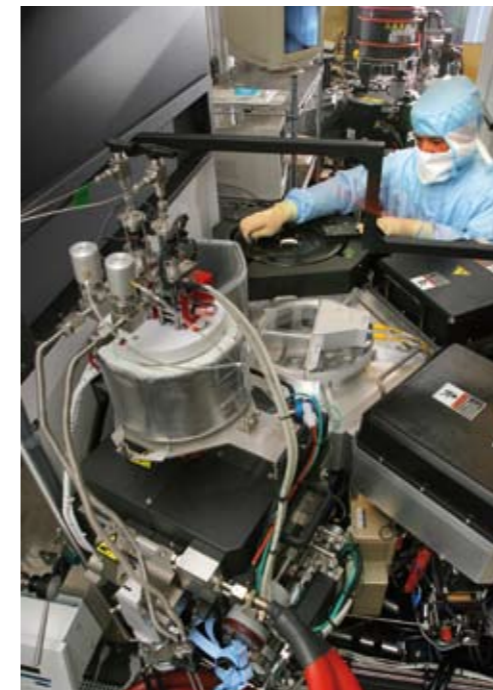


Fig. 2: P5000 used for deposition of Copper

PROCESSES

- High temperature processes: Diffusion / thermal oxidation / annealing / RTP
- Physical Vapour Deposition PVD
 - » Sputtering
 - » Electron beam evaporation
- Chemical Vapor Deposition CVD
 - » Plasma enhanced CVD (PE-CVD)
 - » Low-Pressure CVD (LP-CVD)
 - » Metall-Organic CVD (MOCVD)
- Electroplating: Cu, Ni, Au
- Etching (dry: Plasma- and RIE-mode & wet: isotropic / anisotropic)
 - » Dry etching (Si, SiO₂, Si₃N₄, Polysilicon, Silicides, Al, refr. metals, TiN, Cr, DLC, low k dielectrics)
 - » Wet etching (SiO₂, Si₃N₄, Si, Polysilicon, Al, Cr, Au, Pt, Cu, Ti, W)
- Wafer lithography / Electron beam lithography
- Chemical Mechanical Polishing CMP (Copper, Silicon, SiO₂)

CHARACTERIZATION AND TEST

- MEMS/NEMS
- Nanoelectronic devices
- Parametric testing: Waferprober, HP Test-system
- Characterization of analogue-mixed signal circuits up to 500 MHz

Characterization and modeling of devices from low-voltage and high-voltage micro technologies

ANALYTICS

- Scanning electron microscopy SEM / EDX
- Atomic force microscopy AFM
- Variable angle spectroscopic ellipsometry
- Laser profilometry (UBM, TENCOR FLX-2900)
- Surface profilometer
- US-Microscope
- Tension/Compression testing machine Zwick 4660 universal
- Perkin-Elmer DMA 7e dynamic mechanical analyser
- Micromechanical testing instrument
- Lifetime scanner



Fig. 3: Wafer inspection at the microscope

Department Lithography/Etch/Mask



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The department "Lithography/Etch/Mask" represents the technological basis for all patterning processes of the Center for Microtechnologies and its partners. In a class 4 (ISO 14644-1) clean room a complete process line for mask fabrication and lithography is available:

- Large variety of wet and dry etching steps
- 4" and 6" wafers can be processed
- 5" and 7" mask fabrication
- Partially process tools are available even for 8" wafers
- Optical lithography is based on a mask aligner (up to 8" wafers) and an i-line wafer stepper (up to 6" wafers)

In addition to the conventional lithography processes, the department is experienced with double-side exposure, spray coating on 3D-surfaces and the treatment of special resist types like SU8 by using advanced systems. Furthermore cavities can be filled individually by a special spray robot.

With respect to nanopatterning, a 20 years experience exists within the e-beam lithography field. In combination with about 10 dry etch tools, sub quar-

ter micron structures have been etched into numerous materials. Using resist patterns made by partners and special hard masks, feature sizes smaller than 100 nm have been transferred.

Beside these technology services for internal and external partners – the department is performing R&D projects focusing on dry etching processes and High-Aspect-Ratio-MEMS (HAR-MEMS). This work is addressing applications in microsystems technologies, microelectronics, spintronics and photovoltaics as well. Therefore etching of new materials and surface modification steps are investigated. Based on the developed and patented AIM-Technology (Airgap Insulation of Microstructures) a sensor and actuator fabrication platform is available. Using this technology high performance low-g and vibration sensors are provided to several partners for system integration. For this, much effort has been spent additionally in device characterization at wafer level and yield improvement. Another example of successful technology research is the development of a new thin film encapsulation procedure in order to reduce the package size and costs of the devices.



Fig. 1: Wafer inspection within the lithography clean room

Department Layer Deposition



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The department "Layer deposition" is highly competent in the development and fabrication of conductive and isolating layers and layer stacks for microelectronic and microsystems technologies. For this purpose, the department provides state-of-the-art equipment including a new clean room. The department offers support for advanced process modules for research and development purposes and small volume prototyping. Process modules available include:

Physical Vapor Deposition (sputtering, electron-beam):

- Vertical sputtering system MRC 643 (materials: Ti, TiN, Ta, TaN, Cu)
- Vertical sputtering system MRC 643 (materials: Al, Al-Alloys, Cr, TiW, W)
- R&D sputtering system FHR MS 150 x 4 (materials: Ag, Al, Au, Co, Cr, MoNi, MoFe, Ti, TiN)
- R&D sputtering system FHR MS 150 x 4-AE-B (materials: Al, Al-Alloys, Hf, Pyrex)
- R&D Electron-Beam-Evaporation (materials: Al, Cu, Pd, Pt ...)

Chemical Vapor Deposition (MO-CVD, PE-CVD, LP-CVD):

- MO-CVD R&D system Varian Gartek (materials: Cu, TiN)
- PE-CVD system Precision 5000 Mark II Applied Materials (materials: SiO₂, Si₃N₄, Si_xO_yN_z, SiCOH, SiCH)
- PE-CVD system Plasmalab Plasma Technology (materials: SiO₂, Si₃N₄)
- PE-CVD system Microsys 400 Roth & Rau (material: Diamond-like Carbon)
- LP-CVD system LP-Thermtech (materials: SiO₂, Si₃N₄, polysilicon)

High temperature processes (diffusion / thermal oxidation / annealing / RTP):

For the characterization of the deposited layers and layer stacks we use a lot of measuring methods and systems, for example:

- KLA Tencor surface profiler Alpha step 500
- Thin film stress measurement system TENCOR FLX 2900
- White light interferometer Nanometrics NanoSpec / AFC
- Ellipsometer: Gaertner L11B (632.8 nm)
- Spectroscopic Ellipsometry: Sentech instruments GmbH SE 850 (190 nm – 2550 nm).

Lectures

Chair Microtechnology

Process and Equipment Simulation
Lecturers: Prof. Dr. T. Gessner, Dr. R. Streiter

Advanced Integrated Circuit Technology
Lecturers: Prof. Dr. S. E. Schulz, Dr. R. Streiter

Microelectronics Technology
Lecturers: Prof. Dr. T. Gessner, Prof. Dr. S. E. Schulz,

Micro Technology
Lecturers: Prof. Dr. T. Gessner, Dr. K. Hiller, Dr. A. Bertz

Microoptical systems
Lecturer: Prof. Dr. T. Otto

Technology of Micro and Nanosystems
Lecturers: Prof. Dr. T. Gessner, Dr. K. Hiller

Micro and Nano Technology
Lecturers: Prof. Dr. T. Gessner, Dr. K. Hiller

Lectures of International Research Training Group
Lecturer: Prof. Dr. S.E. Schulz

Chair Microsystems and Precision Engineering

Micro Systems and Devices
Lecturer: Prof. Dr. J. Mehner

Precision Engineering
Lecturer: Prof. Dr. J. Mehner

Microsystems Design
Lecturers: Prof. Dr. J. Mehner, M. Dienel

Reliability and Quality Assurance
Lecturer: Prof. Dr. W. Dötzel

Measurement Technologies for MEMS
Lecturers: Dr. J. Markert, Dr. S. Kurth

Technical Optics
Lecturers: Prof. Dr. J. Mehner, H. Specht

Computer Aided Design
Lecturer: Prof. Dr. J. Mehner

Microsystems for Medical Applications
Lecturer: Dr. A. Mueller (Klinikum Chemnitz)

Chair Circuit and System Design

Integrated Circuit Design
Lecturer: Prof. Dr. U. Heinkel

System Design
Lecturer: Prof. Dr. U. Heinkel

EDA-Tools
Lecturer: Prof. Dr. U. Heinkel

Rapid Prototyping
Lecturer: Prof. Dr. U. Heinkel

ASIC Design
Lecturer: Prof. Dr. U. Heinkel

Components and Architectures
Lecturer: Prof. Dr. G. Herrmann

Computer Technology
Lecturer: Prof. Dr. G. Herrmann

Microprocessor Systems
Lecturer: Prof. Dr. G. Herrmann

Processor Design
Lecturer: Prof. Dr. G. Herrmann

Micro Production Technologies (BTU Cottbus)
Lecturer: Prof. Dr. G. Herrmann

Micro Systems (BTU Cottbus)
Lecturer: Prof. Dr. G. Herrmann

Micro Assembly Technologies (BTU Cottbus)
Lecturer: Prof. Dr. G. Herrmann

Chair Electronic Devices of Micro and Nano Technique

Electronic Devices and Circuits
Lecturer: Prof. Dr. J. Horstmann

Electronic Devices
Lecturer: Prof. Dr. J. Horstmann

Fundamentals, Analysis and Design of Integrated Circuits
Lecturer: Dr. S. Heinz

Integrated Analog Circuit Design
Lecturer: Dr. S. Heinz

Fundamentals of Electronics
Lecturer: Prof. Dr. J. Horstmann

Physical and Electrical IC Design
Lecturer: Dr. S. Heinz

Microelectronics
Lecturer: Dr. S. Heinz

Devices of Micro- and Nano Technique
Lecturer: Prof. Dr. J. Horstmann

Micro- and Nano Devices
Lecturer: Prof. Dr. J. Horstmann

Integrated Circuit Design – Transistor Level
Lecturer: Dr. S. Heinz

Lithography for Nanosystems
Lecturer: Prof. Dr. J. Horstmann

Chair Power Electronics and Electromagnetic Compatibility

Power Electronics
Lecturer: Prof. Dr. J. Lutz

Semiconductor Power Devices
Lecturer: Prof. Dr. J. Lutz

Design and Calculation of Power Electronic Systems
Lecturer: Prof. Dr. J. Lutz

Industrial Electronics
Lecturer: Prof. Dr. J. Lutz

Energy Electronics
Lecturers: Prof. Dr. J. Lutz, Dr. S. Koenig

Simulation of Electroenergetic Systems
Lecturers: Prof. Dr. J. Lutz, Dr. S. Koenig

Chair for Measurement and Sensor Technology

Electric Measurement Technology
Lecturers: Prof. Dr. O. Kanoun, Prof. Dr. N. Kroemer

Electronic Measurement Technology
Lecturer: Prof. Dr. O. Kanoun

Smart Sensor Systems
Lecturer: Prof. Dr. O. Kanoun

Sensor Signal Processing
Lecturer: Prof. Dr. O. Kanoun

Sensors and Actuators
Lecturer: Prof. Dr. O. Kanoun

Automotive Sensors
Lecturer: Prof. Dr. O. Kanoun

Praxis Seminar Measurement and Sensor Technology
Lecturer: Prof. Dr. O. Kanoun

Fundamentals of Technical Optics
Lecturer: Dr. M. Arnold

Optoelectronic
Lecturer: Dr. M. Arnold

Photonics
Lecturer: Dr. M. Arnold

Chair for Materials and Reliability of Microsystems

Reliability of Micro and Nanosystems
Lecturer: Prof. Dr. B. Wunderle

Materials of Microsystems and Precision Engineering
Lecturer: Prof. Dr. J. Fruehauf

Materials of Electrical Engineering and Electronics
Lecturer: Prof. Dr. J. Fruehauf

Materials of Micro Technology
Lecturer: Prof. Dr. J. Fruehauf



Fig. 1: Bird view of the Smart Systems Campus Chemnitz with Fraunhofer ENAS (left side), Institute of Physics and new clean room of Center for Microtechnologies (in the middle), old yellow building of Center for Microtechnologies (right), orange building of 3D-Micromac AG (left side, upper part) and start-up building (right to Fraunhofer ENAS)

Cooperation

Since 1998 a strong cooperation exists between the Center for Microtechnologies ZfM and the Fraunhofer Research Institution for Electronic Nano Systems ENAS developed out of the former Chemnitz branch of Fraunhofer IZM. The Fraunhofer ENAS focuses on smart systems integration by using micro and nano technologies. The integration of nano materials as well as printed functionalities causes new challenges and requires new approaches in terms of reliability, testability, design and security.

In near future systems will be quite more intelligent and multifunctional. For that reason the integration of electronics for signal and information processing with sensors and actuators in silicon and nonsilicon technologies. is a main task The main research activities of the Fraunhofer ENAS Chemnitz can be divided in the following topics:

- Multi Device Integration: development of MEMS/NEMS, prototyping of sensor and actuator devices, integration of such devices together with micro and nano-electronic components to systems, design of components and systems, development and implementation of test and characterization of MEMS/NEMS
- System Packaging: core competence in development and application of wafer bonding processes for MEMS packaging (chip and wafer bonding including combinations of new materials and bonding at low temperatures), 3D-patterning technologies for silicon and non silicon materials, CMP (chemical mechanical polishing)
- Back-end of Line (BEOL): advanced metallization systems for the leading edge technology, 3D-integration and interconnects, new materials (copper, low k materials, CNTs,...) for advanced metallization, simulation of process and equipment
- Reliability of Micro and Nanosystems: thermo-mechanical reliability of micro and nano components in high tech systems, core competence combination of thermo-mechanical simulation with advanced experimental methods
- Printed Functionalities: utilizing inkjet and mass printing technologies for efficient industrial fabrication processes

of printed components for smart systems, technology development and adapted measurement technique

The department managers of the department Multi Device Integration and Back-end of Line work as honorary professors at the Chemnitz University of Technology.

Both, Fraunhofer ENAS and ZfM, belong to the Smart Systems Campus Chemnitz, which has been finalized within 2009. The Smart Systems Campus Chemnitz is an innovative network with expertise in micro and nano technologies as well as in smart systems integration. This technology park provides renowned scientific and technical centers with the entrepreneurial spirit and business acumen and an economic boost at a location where everything is on the spot. A close integration of science, applied research and industry is there an everyday reality and reflects a strategy that is being fulfilled.

The start-up building for companies related to the sector mentioned before forms an important part of the campus. There is space for approx. 15 start-up companies. In the present time the following companies are working there:

- Berliner Nanotest und Design GmbH (common labs with EUCEMAN, CWM, AMIC GmbH, Amitronics GmbH, SEDEMAT GmbH, Clean Technologies Campus GmbH)
- memsfab (common lab with Leibniz IFW)
- EDC Electronic Design Chemnitz GmbH
- LSE Lightweigh Structures Engineering GmbH
- SiMetrics GmbH

The business park allows expanding companies to set up in business in the very neighbourhood. The first company in the park is the 3D-Micromac AG which develops and manufactures highly efficient and innovative machines for laser micro machining.

Cooperation within Center of Competences



The research consortium nanett „nano system integration network of excellence - application of nano technologies for energy-efficient sensor systems“ is one of the successful initiatives of the second phase of the “Spitzenforschung und Innovation in den Neuen Ländern“ program, funded by the Federal Ministry of Education and Research (BMBF). Under the direction of the Chemnitz University of Technology and the Fraunhofer Research Institution for Electronic Nano Systems ENAS this dynamic network of nine different partners was formed to bring together their competences in the field of applied nano technologies. Using that approach of combining the capabilities of several renowned scientific institutions enables international and domestic top level research on a competitive basis. The grant of the BMBF for the whole R&D joint venture amounts to 14 million Euros. The project started November 2009 at a duration of 5 years.

The greatest concern of the network is to be an attractive, competent and solid partner of the industry in the promising domain of nano and system integration technologies. To suit the requirements of high interdisciplinarity and due to huge invest costs for production and test equipment in the field of micro and nano technologies the usage of synergies by collaboration of different oriented research centers is essential for success and efficiency of joint research projects.

The following partners are cooperating within the nanosystem integration network of excellence:

- Chemnitz University of Technology (Faculty of Electrical Engineering and Information Technology, Faculty of Natural Sciences, Faculty of Mechanical Engineering and Faculty of Computer Science)

- the University of Applied Sciences Mittweida (FH)
- three Fraunhofer Institutes (Fraunhofer ENAS, Fraunhofer IZM and Fraunhofer IAP) t
- three Institutes of the Leibniz Association (Leibniz IHP, Leibniz IFW and Leibniz IPF)
- the Helmholtz Zentrum Berlin (HZB)

Fields of research are:

NOVEL PROCESSES AND TECHNOLOGIES

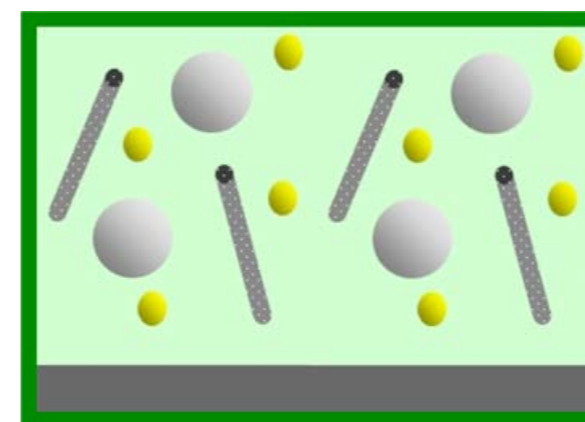
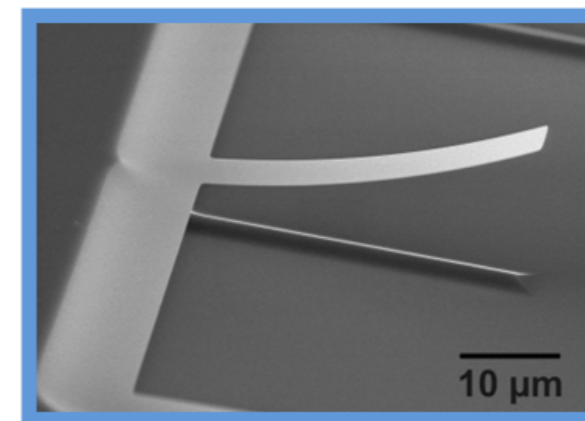
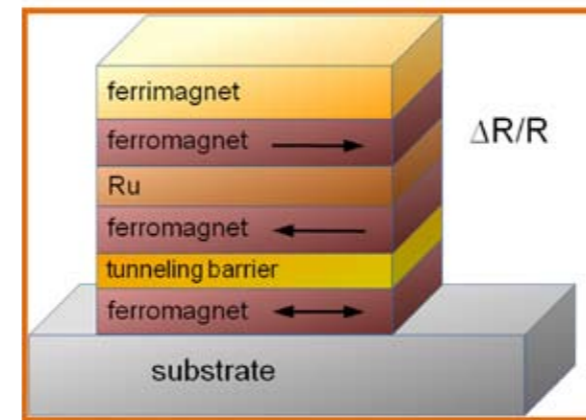
- Application of quantum mechanical phenomena and effects of nano structures
- Significant improvement of resolution

MICRO-NANO-INTEGRATION

- Integration of nano structures with electromechanical functionalities
- “Enabling technology“ for implementation of new functionalities

NANO MATERIALS

- Functional nano composite materials
- Integration of sensor technologies and actuator
- Engineering into constructional elements



Objectives:

The most important objectives of the network are:

- Increase of the international visibility of the involved partners, especially of scientific and technical centers located at the Smart Systems Campus in Chemnitz by focusing of competencies and integration of excellent scientists in promising application-oriented projects
- Combination of different research areas in common projects to suit the interdisciplinary requirements of nano system integration technology
- Link of universities, applied research centers and local industry at a supra-regional level to enable know-how and technology transfer as well as to improve its innovative energy
- Increase of added value of local small and medium-sized enterprises and therefore its competitiveness by implementation of smart components and systems into products
- Strength of attractiveness of R&D institutions for students and graduates by offering collaborations within ambitious and industry relevant research fields

For more information please visit our website: <http://www.nanett.org/>

Cooperation within the IRTG 1215 Materials and Concepts for Advanced Metallization

Since April 1st, 2006, the International Research Training Group (Internationales Graduiertenkolleg 1215) "Materials and Concepts for Advanced Interconnects", jointly sponsored by the German Research Foundation (DFG) and the Chinese Ministry of Education, has been established for 4.5 years between the following institutions:

- Chemnitz University of Technology with Institute of Physics, Institute of Chemistry and Center for Microtechnologies
- Fraunhofer Research Institution for Electronic Nano Systems ENAS
- Fraunhofer Institute for Reliability and Micro-integration IZM
- Technical University Berlin
- Fudan University, Shanghai
- Shanghai Jiao Tong University

This International Research Training Group IRTG 1215 is the first of its kind at Chemnitz University of Technology. It is lead by Prof. Ran Liu of Fudan University as the coordinator on the Chinese side and Prof. Thomas Gessner on the German side. A graduate school like this offers brilliant young PhD students the unique opportunity to complete their PhD work within 2.5 to 3 years in a multidisciplinary environment. Up to 14 PhD students of the German and 20 of the Chinese partner institutions as well as a post-doctoral researcher at the Center for Microtechnologies are involved in the current program. The different individual backgrounds of the project partners bring together electrical and microelectronics engineers, materials scientists, physicists, and chemists. In particular, the IRTG is working to develop novel materials and processes as well as new concepts for connecting the devices within integrated microelectronic circuits. Smaller contributions are being made in the field of device packaging and silicides for device fabrication. In this sense, the IRTG project is helping to solve problems currently encountered on the way to nanoelectronics.

Therefore, the research program of the IRTG concentrates on both applied and fundamental aspects, and treats the mid- and long-term issues of microelectronics metallization. Atomic layer deposition (ALD) of metals, new precursors for metal-organic chemical vapor deposition (MOCVD), ultra low-k dielectrics and their mechanical and optical characterization together with inspection techniques on the nanoscale are considered. New and innovative concepts for future microelectronics such as carbon nanotube interconnects or molecular electronics along with silicides to form links to front-end of line processes are of interest, as well as the evaluation of manufacturing-worthy advanced materials. Moreover, the research program addresses reliability and packaging issues of micro devices. Highlighting links between fundamental materials properties, their characteristics on the nanoscale, technological aspects of materials and their applications to microelectronic devices is the main objective of the program.

Nevertheless, the principal idea of the IRTG is four-fold: The research program defines the framework of the activities and the topics of the PhD theses. This is accompanied by a specially tailored study program including lectures, seminars and laboratory courses to provide comprehensive special knowledge in the field of the IRTG. The third part of the program comprises annual schools held either in China or Germany, bringing together all participants of the IRTG and leading to vivid discussions during the presentation of the research results. Moreover, an exchange period of 3 to 6 months for every PhD student at one of the foreign partner institutions is another essential component. Besides special knowledge in the scientific field, these activities will provide intercultural competencies that cannot easily be gained otherwise.

Summer School 2009:

The 4th summer school of the International Research Training Group 1215 was held from May the 12th to the 17th, 2009 in Shanghai. This event was organized by Prof. Chen Di of the Shanghai Jiao Tong University.

At the first two days of the summer school (May 13th and 14th), 26 PhD students from the German and Chinese party presented the status and progress of their work. For some of the presenters it was their first attendance to the annual summer school. Each presentation closed-up by questions from the audience. The international participants had the opportunity for further discussions as well as small talk during breaks for tea and meals.

The events were organized at both, the old and new campus of the Shanghai Jiao Tong University. The guests had an impressive visit of the very large new campus.

On May 15th, the preparation of the new proposal for the International Research Training Group took the center stage of the involved professors. The event was opened by Prof. Thomas Gessner, speaker of the International Research Training Group. He demonstrated the activities of the Fraunhofer Research Institution for Electronic Nano Systems ENAS and the Center for Microtechnologies in connection with actual trends and processes in micro and nanotechnologies. Afterwards, the representatives of the single subprojects presented the focuses of prospective activities. Nine German and 11 Chinese subprojects for the follow-up application were already defined in advance. During the meeting, contents were discussed and possible interfaces as well as cooperations between the projects were pointed out.

A sight-seeing-tour for the PhD students was planned. They visited the Suzhou Industrial Park, the Bio Bay, the Suzhou Institute of Nano-Tech and Nano-Bionics (SNANO) and gained insight of the activities of the respective institution. Following, as part of the cultural framework program, the Humble Administrator's Garden (Zhuozheng Yuan) and the The Tiger Hill (Hu Qiu) were visited.

On May 16th, all participants of the summer school could enjoy an impressive performance of Chinese acrobatics in the arts center Shanghai Circus World.

Due to earlier exchanges (mobility periode) of several PhD students between the Chinese and the German side, the event was accompanied by an active commu-

nication of all members. Especially the cultural framework program in a nice atmosphere made the communication between the participants of the summer school really pleasant.

On May 17th the event was completed by the dinner for the German guests and Chinese organizers. According to the attendants, the organization of this year's summer school was excellent.

For three German PhD students the summer school took place during their three-month exchange stay abroad in China. They were integrated very well in their respective groups and discovered good working conditions.

New proposal:

Beside the research activities of the IRTG program the preparation of the new project proposal was the main focus of the work in 2009. The new topic will be "Materials and Concepts for Advanced Interconnects and Nanostructures". The new topic combines both, "More Moore" as well as "More than Moore" related activities. The proposal was submitted to the German Research Foundation (DFG) at the end of October 2009. The evaluation of the first period of the IRTG program by the German Research Foundation is scheduled for the end of March 2010.

For further information please visit our webpage: <http://www.zfm.tu-chemnitz.de/irtg/>

Networks

Networking is our formula for success. The Center for Microtechnologies is working in several national and international networks.



Silicon Saxony

Silicon Saxony e.V. is Europe's largest trade association for the microelectronic industry.

It was founded in 2000 as a network for the semiconductor, electronic and micro system industry. The association connects manufacturers, suppliers, service providers, colleges, research institutes and public institutions in the economic location of Saxony. The current number of members has risen to 270. The member companies employ about 35,000 people and the total turnover of the companies is 4 billion € per year. The ZfM belongs to the foundation members.

13 working groups are working within the network. The working group "Smart Integrated Systems" has been founded 2007. It is led by Prof. Thomas Gessner.

In 2009 Prof. Thomas Gessner became a member of Silicon Saxony Board.



IVAM

As international association of companies and institutes in the field of micro technology, nano technology and advanced materials, IVAM's priorities are to create competitive advantages for our members. Nearly 300 member companies and institutes from 20 countries open up new markets and set standards with the support of IVAM. Companies, institutes, products, services and contact persons are listed here online as well as in the printed IVAM directory. The Center for Microtechnologies is a member of the IVAM network since 2005.

Within 2007 Prof. Gessner became a member of IVAM Advisory Council. The IVAM Advisory Council helps impulses from application oriented science to be integrated into the work of the association. Apart from their consulting function, the members of the IVAM Advisory Council also represent IVAM in public.

Nanotechnology Center of Competence "Ultrathin Functional Films"



nanotechnologie

CC "Ultradünne funktionale Schichten"

The Center of Competence "Ultrathin Functional Films" (CC-UFF) is coordinated by Fraunhofer IWS Dresden. It joins 51 enterprises, 10 university institutes, 22 research institutes, and 5 corporations into a common network. Activities within the frame of Nano-CC-UFF are subdivided into 6 working groups, each of them is administered and coordinated by one member.

- WG 1: Advanced CMOS
- WG 2: Novel components
- WG 3: Biomolecular films for medical and technological purposes
- WG 4: Mechanical and protective film applications
- WG 5: Ultrathin films for optics and photonics
- WG 6: Nano-size actuators and sensors

Working group 1 is headed by Prof. Thomas Gessner and working group 2 by Prof. Christian Radehaus (former member of the board of directors of the Center for Microtechnologies of Chemnitz University of Technology).

Imprint:

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