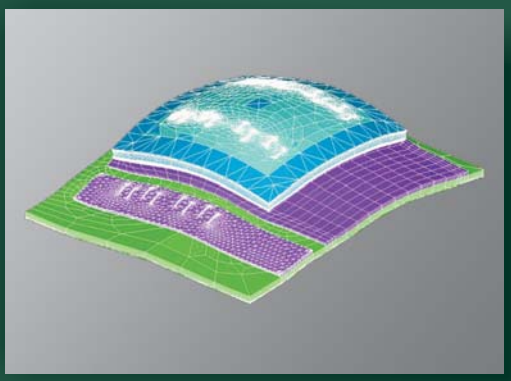
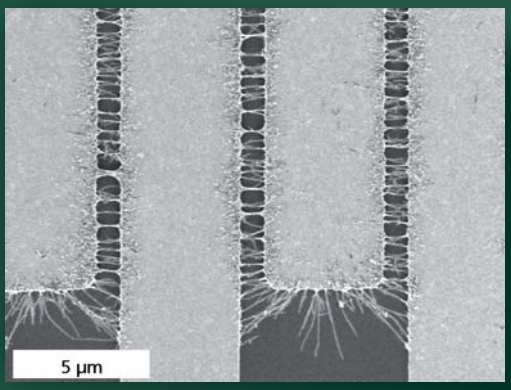
CHEMNITZ UNIVERSITY OF TECHNOLOGY

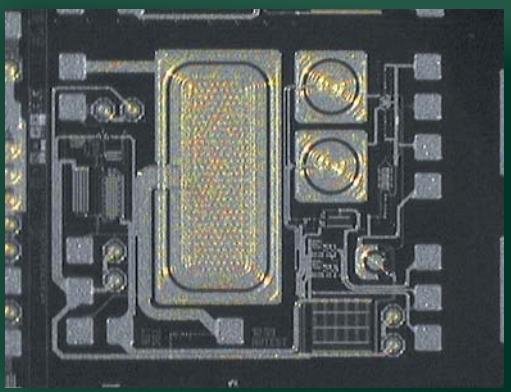
FACULTY OF ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY

CENTER FOR MICROTECHNOLOGIES

ANNUAL REPORT 2008







ZfM
Zentrum für Mikrotechnologien

CHEMNITZ UNIVERSITY OF TECHNOLOGY

Information online: www.zfm.tu-chemnitz.de

Contents

Center for Microtechnologies

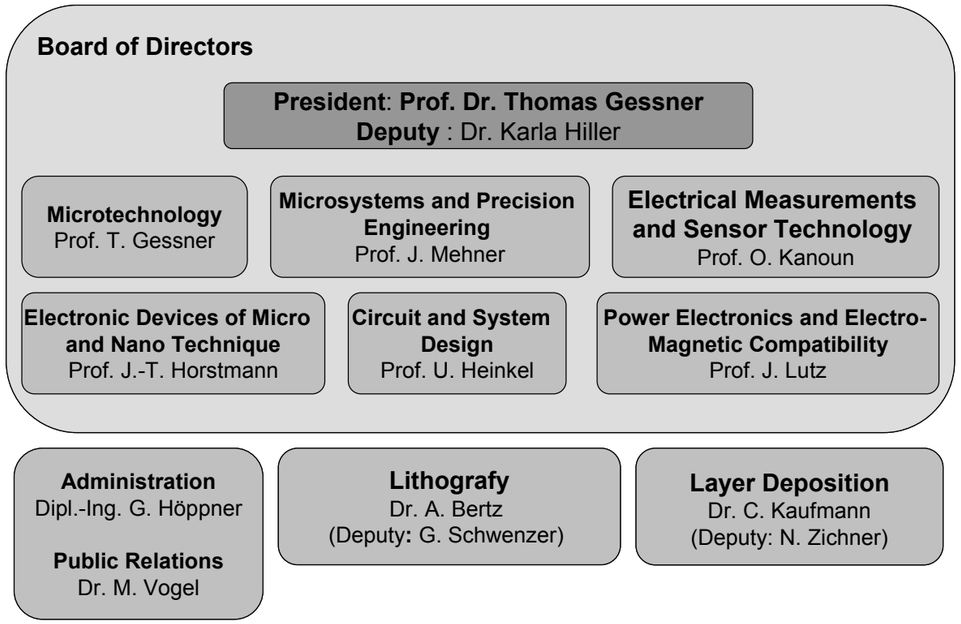
The Center for Microtechnologies (ZfM) founded in 1991, belongs to the department of Electrical Engineering and Information Technology of the Chemnitz University of Technology. It is the basis for education, research and developments in the fields of micro and nano electronics, micro mechanics and microsystem technologies in close cooperation with various chairs of different TUC 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 had a tradition and experience for more than 30 years in the fields of microsystem technology, micro and nano electronics, as well as opto-electronics and integrated optics.

Within 2008 Prof. Radehaus left the Center for Microtechnologies. At this place we want to thank him again for this scientific work, his commitment and his support. A new member of the board of directors of ZfM is Prof. Olfa Kanoun. She is the Chair of Electrical Measurements and Sensor Technology.

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 micro systems and nano systems (sensors, actuators, arrays, back-end of line)
- Design of components and systems
- Nanotechnologies, nano components and ultra-thin functional layers



Visit our homepage: http://www.zfm.tu-chemnitz.de

Chair Microtechnology

Contact: Prof. Dr. Thomas Gessner

Phone: +49 (0)371 531 33130

Email: thomas.gessner@zfm.tu-chemnitz.de

Main working fields:

- Development of new materials and processes for metallization systems in micro and nanoelectronics
- Simulation of equipment and processes for micro and nanoelectronics
- Development of nanotechnologies, nano components and ultra-thin functional films
- Development of plasma processes for photovoltaics
- Development of technologies and components for micro and nanosystems (sensors, actuators and arrays)
- 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
- Encapsulation by wafer bonding
- Encapsulation by thin film technology

Based on the patented AIM technology a new generation of inertial sensors has been developed. They are used for "freefall" detection, vibration control, tilt sensing for antitheft, shock monitoring, airbag release and dead reckoning. Essential issues for these devices are: fabrication effort including yield, signal to area ratio, calibration effort, signal to noise ratio and temperature drift.

Further examples of the development of micromechanical sensors and actuators are micromachined tunable Farby-Perot Infrared filter, Fig. 1, and polymer cartridge for biosensing applications, Fig. 2.

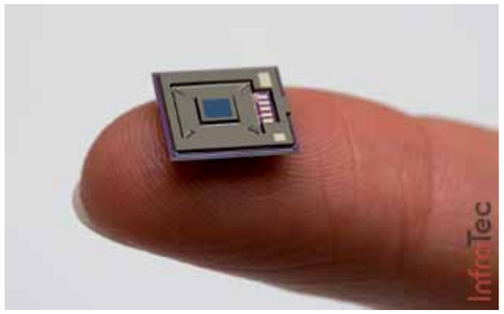


Fig.1: Micromachined tunable Farby-Perot Infrared filter

Current approaches for NEMS technologies are based on:

- Thin and ultra-thin films
- Sub-µm gaps
- Carbon nanotubes

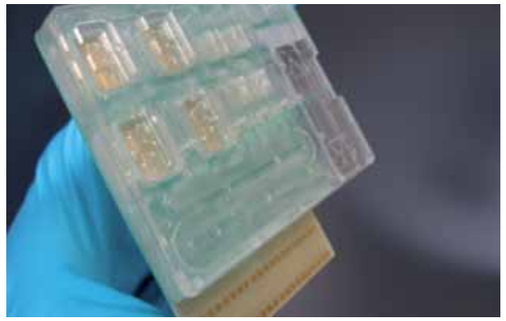


Fig.2: Polymer cartridge for biosensing applications with active and passive fluid handling and SPR nanosensors

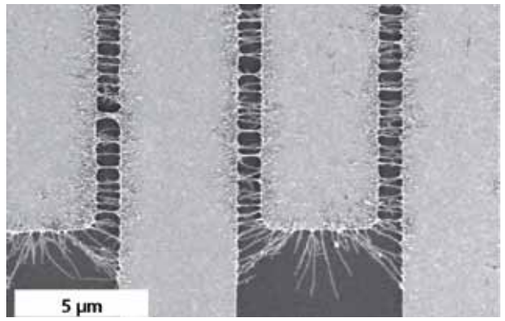


Fig.3: Aligned SWNTs deposited with DEP on electrode arrays

Carbon Nanotubes are investigated for interconnect systems and NEMS, Fig. 3

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.

Thin films, both conductive and insulating, are especially important for wiring the hundreds of millions of transistors in a microprocessor, forming a multilayer interconnect system. The current activities include the development of atomic layer deposition of copper, Fig. 4, ultra-thin diffusion barriers, Fig. 5, as well as the application of carbon nanotubes for future nanoscale interconnects. Several of these topics are being treated within the International Research Training Group on "Materials and Concepts for Advanced Interconnects", a joint PhD program together with Fudan and Jiao Tong University in Shanghai, two first-class Chinese universities.

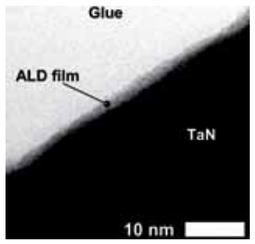


Fig.4: Cross-sectional TEM micrograph of a Cu/CuxO composite film deposited by ALD on TaN at 125°C.

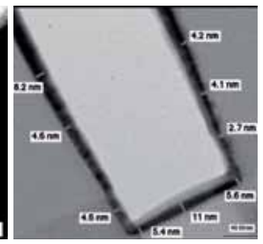


Fig.5: TEM micrograph of a WNx diffusion barrier film deposited by CVD into a SiO_2 trench 160 nm in width and 500 nm deep.

Selected publications:

Hermann, S.; Ecke, R.; Schulz, S.E.; Gessner, T.: **Controlling the formation of nanoparticles for definite growth of carbon nanotubes for interconnect applications**. MAM 2008, Dresden (Germany), 2008 March 8-11; Microelectronic Engineering, Volume 85, Issue 10 (2008) pp. 1979-1983

Leidich, S.; Kurth, S.; Gessner, T.: **Continuously Tunable RF-MEMS Varactor for High Power Applications**. IEEE MTT-S International Microwave Symposium, Atlanta (USA), 2008 June 15-20; Proceedings, pp. 1267-1270

Nestler, J.; Hiller, K.; Otto, T.; Gessner, T.: **Micro Actuators based on Structured Water**. MST-News (international magazine on smart systems integration), June 2008 (2008) pp. 18-21

Chair Microsystems and Precision Engineering

Contact: Prof. Dr. Jan Mehner

Phone: +49 (0)371 531 24430

Email: jan.mehner@etit.tu-chemnitz.de

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 harvesting

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, and other).

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.

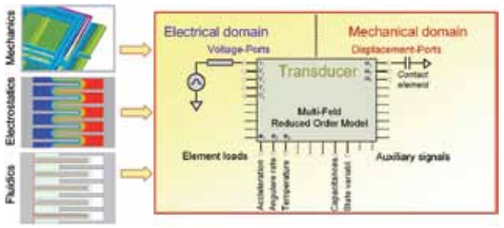


Fig.1: Reduced order modeling for microsystems design

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

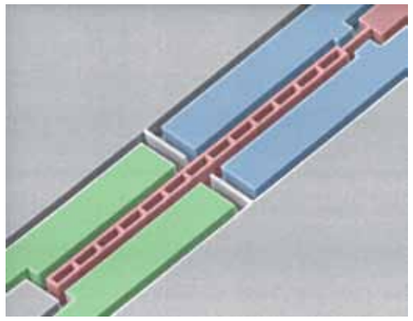


Fig.2: Zoomed and colored view of a vibration sensor for machine noise detection

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 Micro System 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 allows 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

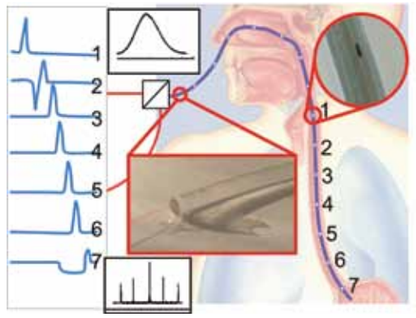


Fig.4: Working principle of a medical pressure sensor catheter for esophageal diagnosis

Selected Publications:

Gerlach, G.; Dötzel, W.: **Introduction to Microsystem Technology: A Guide for Students**. Wiley, Hardcover, 376 pages, March 2008

Forke, R.; Scheibner, D.; Hiller, K.; Gessner, T.; Dötzel, W.; Mehner, J.: **Fabrication and Characterization of a Force Coupled Sensor-Actuator System for Adjustable Resonant Low Frequency Vibration Detection**. Sensors and Actuators A: Physical, Vol. 145-146, 2008 Jul-Aug, pp. 245-256

Kolchuzhin, V.; Dötzel, W.; Mehner, J.: **Efficient Generation of MEMS Reduced-Order Macromodels Using Differentiation of Finite Elements**. Sensor Lett., Vol. 6, No. 1, 2008 Feb, pp. 97-105

Shaporin, A.; Forke, R.; Schmiedel, R.; Dötzel, W.: **Test-Structures for Wafer Level Microsystems Characterization**. Smart Systems Integration, Barcelona (Spain), 2008 Apr 9-11, Proceedings, pp. 528-531

Tenholte, D.; Kurth, S.; Hiller, K.; Kaufmann, C.; Gessner, T.; Dötzel, W.; Mehner, J.: **A MEMS Friction Vacuum Gauge**. Eurosensors XXII, Dresden (Germany), 2008 Sep 7-10, Proceedings, pp. 206-209

Chair Circuit and System Design

Contact: Prof. Dr.-Ing. Ulrich Heinkel

Phone: +49 (0)371 531 24310

Email: ulrich.heinkel@etit.tu-chemnitz.de

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 TU Chemnitz
- 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, an extensive 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,
- utilisation 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's 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 these 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
- BMBF-Project URANOS „Analysemethoden für den Entwurf anwendungsrobuster nanoelektronischer Systeme"
- BMBF-Projekt Netz der Zukunft - Mx Mobile „Multi-Standard Mobile Platform" (Teilvorhaben: Kostenmodellierung zur verbesserten Design Space Exploration)
- BMBF-Projekt „Mx Mobile „Multi-Standard Mobile Platform" Phase 1"
- BMBF-Project Herkules „Hardwareentwurfstechnik für Null-Fehler-Designs"
- Robo Tools „Entwicklung einer funkbasierten Kontroll- und Steuereinheit von Robotern zur Fernwartung"
- SAB-Project „Entwicklung eines integrierten digitalen Sensors zur berührungslosen Längen- und Geschwindigkeitsmessung an bewegten nichtleitenden Materialien", Teilthema „Entwicklung einer digitalen Sensorsignalverarbeitung"

Selected Publications:

Pross, U.; Markert, E.; Langer, J.; Richter, A.; Drechsler, C.; Heinkel, U.**: A Platform for Requirement Based Formal Specification**. FDL´08 (Forum on Specification & Design Languages), Stuttgart, 23.-25. September 2008, IEEE Catalog Number CFP0826E-USB, ISBN 978-1-4244-2266-1, pp. 237-238, Library of Congress 2008901976

Markert, E.; Pross, U.; Heinkel, U. **: SpecScribe Analog - A Specification Tool Extension for Heterogeneous Systems**. FDL´08 (Forum on Specification & Design Languages), Stuttgart, 23.-25. September 2008, IEEE Catalog Number CFP0826E-USB, ISBN 978-1-4244-2266-1, pp. 243-244, Library of Congress 2008901976

Rößer, M.; Heinkel, U.**: Preemptive HW/SW-Threading by combining ESL methodology and coarse grained reconfiguration**. Konferenz ReCoSoc08, Barcelona, 9.-11. Juli 2008

Billich, E.; Rößer, M.; Heinkel, U.**: Optimale HW/SW-Partitionierung einer MPEG-Codierung mit dem High-Level ESL-Werkzeug CoDeveloper**. Dresdner Arbeitstagung Schaltungs- und Systementwurf DASS, Dresden, 15.-16. Mai 2008, S. 79-84, ISBN 3-9810287-2-4

Tischendorf, C.; Langer, J.; Proß, U.; Heinkel, U.**: Generierung von VHDL-Modellen aus PSL-Eigenschaften**. Dresdner Arbeitstagung Schaltungs- und Systementwurf DASS, Special session URANOS, Dresden, 15.-16. Mai 2008, S. 37-42, ISBN 3-9810287-2-4

Markert, E.; Zeun, H.; Herrmann, G.; Müller, D.; Heinkel, U.**: SystemC-AMS-Modell eines DeltaC-U-Wandlers für ein Inertialnavigationssystem**. Workshop "Detektion mit und in Biosystemen", 10. April 2008, Bio City Leipzig

Wolf, P.; Markert, E; Herrmann, G.; Heinkel, U.**: Eine generische Plattform zur Sensorsignalauswertung**. Workshop "Detektion mit und in Biosystemen", 10. April 2008, Bio City Leipzig

Pross, U.; Richter, A.; Langer, J.; Markert, E.; Heinkel, U.**: SpecScribe - Specification data capture, analysis and exploitation**. DATE´08, Munich, 10.-14. März 2008, Software Demonstration at DATE´08 University Booth

Chair Electronic Devices of Micro and Nano Technique

Contact: Prof. Dr. John Thomas Horstmann

Phone: +49 (0)371 531 37114

Email: john-thomas.horstmann@etit.tu-chemnitz.de

Main working fields:

- layout and verification of analog- and mixed-signal circuit designs for microsystem technology
- manufacturing, analysis and characterization of next-generation nano electronic devices
- sub-50nm-MOS-transistors modelling
- integrated circuit design for microsystem electronics, especially low noise, low power and high voltage
- sensor signal evaluation and actuator control of microsystems
- modeling and simulation of electronic devices for microsystem electronics

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

- invention of new materials in the CMOS-process for next generation nano devices
- new circuit concepts for nano electronic mechanical systems
- development of measurement methods for the analysis of the electrical parameters of next generation nano electronic devices
- analysis of the physical mechanisms of micro and nano electronic devices
- simulation and characterization of sub-50nm-MOS-transistors
- development of strategies to reduce the statistical parameter fluctuations of very small MOS-transistors
- Investigation and evaluation of the trench isolations and characterization of the electrical parameters

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

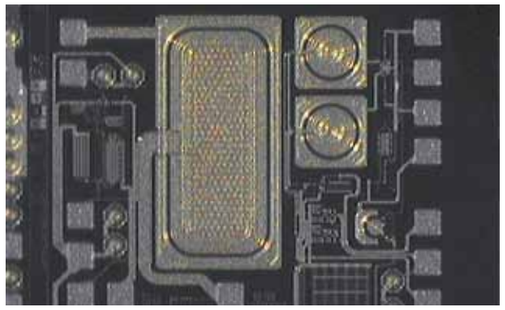


Fig.2: Example for an electronic micro system

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 the 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 1µm-CMOS-technology with monolithic integrated pressure sensors.
- Development of modern electrical drive systems like electric motors with high efficiency and smart-power-control-concepts.
- In-Die parameter variation for the characterization of semiconductor structures in nano technologies and the conception of adapted measuring strategies.
- 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.

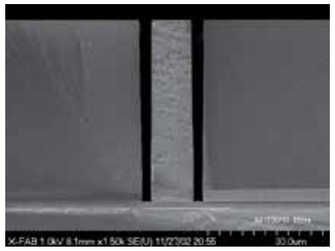


Fig.3: Cross-sectional picture of a double trench [X-FAB]

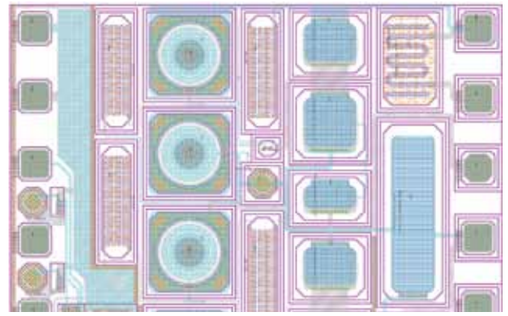


Fig.4: Layout of a electronic micro device

Example for an integrated smart-power application:

Electrostatic driven micromechanical components with capacitive behaviour 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.

Selected Publications

Horstmann, J. T.; Kallis, K. T.; Fiedler, H. L.**: Experimental Threshold Voltage Fluctuations of 30-nm-NMOS-Transistors Manufactured by a Lithography Independent Structure Definition Process**. 34th International Conference on Micro and Nano Engineering 2008, MNE 2008, Athens, Greece, 15-18 September 2008

Heinz, S.**: Integrierte Hochvolt-Schaltungstechnik: Ansteuerschaltungen für Mikroaktoren mit elektrostatischem Antrieb**. Vdm Verlag Dr. Müller, ISBN-10: 3-639-05903-4, Juli 2008

Lerner, R.; Eckoldt, U.; Schottmann, K.; Heinz, S.; Erler, K.; Lange, A.; Ebest, G.**: Time dependent isolation capability of high voltage deep trench isolation**. 20th International Symposium on Power Semiconductors Devices and ICs, May 2008, ISPSD ‘08, Orlando, ISBN 978-1-4244-1532-8

Chair Electrical Measurements and Sensor Technology

Contact: Prof. Dr.-Ing. Olfa Kanoun

Phone: +49 (0)371 531 36931

Email: kanoun@ieee.org

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 processes and products.

The research activities at the chair for electrical measurements 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 working on impedance spectroscopy, energy harvesting and sensors based on carbon nanotubes (CNTs).

Impedance spectroscopy involves improvements of measurement information and permits the extraction of spectrally distributed information. It provides extended possibilities to separate effects, to improve accuracy of measurement and to determine inaccessible measurement quantities. The experience of the chair for electrical measurements and sensor technology in the field of impedance spectroscopy includes many different applications and methodological contributions involving the main aspects of measurement techniques, physical-chemical modeling and signal processing.

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. In order to bridge low energy availability, system should be capable to accumulate superfluous energy and to manage

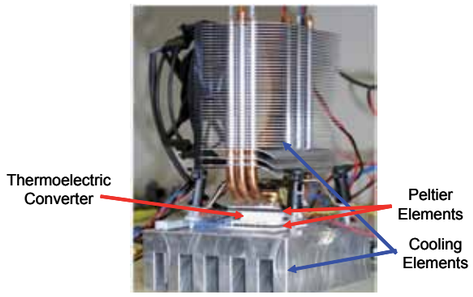


Fig.1: Experimental Setup for Characterization of Thermo Electric Converters

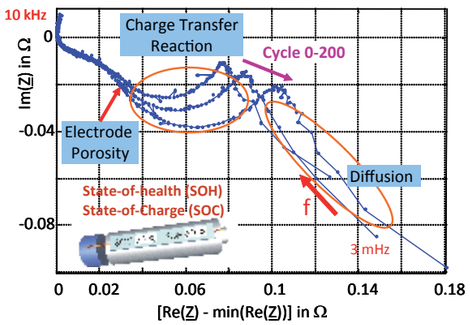


Fig.2: Diagnosis of Li-ion batteries by impedance spectroscopy

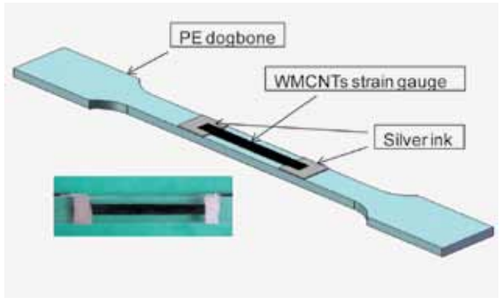


Fig.3: Strain Gauges based on MWCNTs Films

energy flow 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 and 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. They can be manufactured in different forms, show a large sensitivity and are self adhesive so that adhesive can be avoided.

Research areas include

- Battery Diagnosis (state of charge, state of health, state for function)
- Material Testing by Impedance Spectroscopy
- Soil moisture measurement independent on soil type
- Availability and conversion of ambient energy
- Design of energy autonomous systems
- Energy conversion from electrostatic field
- Smart energy management
- Strain gauges based on Carbon Nanotubes (CNT)
- Time Domain Reflectometry (TDR)
- Calibration-free temperature measurement using p-n Junctions

Selected Publications

Kanoun, O.: **Measurement Methods for Material Testing: Manifold prospects**. Special Issues in the scientific Journal: "Technisches Messen", Technisches Messen, Volume 75 (2008), Issue 6 and 9

Kanoun, O.; Fahem, Z.: **Potential of Carbon Nanotubes for Sensor Applications**. Fifth IEEE Conference on Systems, Signals and Devices 2008, July 20-23, Amman, Jordan

Vendramin, G.; Ben Amor, N.; Lay-Ekuakille, A.; Kanoun, O.; Specchia G.; Trotta, A.: **Energy Harvesting from Human Body Movements for Biomedical Auto-nomous Systems**. IEEE Sensors, 26.-29. Oktober 2008, Lecce (Italien)

Keutel, T.; Ben Amor, N.; Zhao, X.; Kanoun, O.: **Characterization of Energy Harvesting Systems at Component and System Level**. Eurosensors XXII, S. 1494-1497, Dresden, 07.-10. September 2008

Cuadras, A.; Tröltzsch, U.; Kanoun, O.: **Low Energy Budget Battery Monitoring**. Eurosensors XXII, S. 1490-1493, Dresden, 07.-10. September 2008

Cuadras, A.; Ben Amor, N.; Kanoun, O.: **Smart Interfaces for Low Power Energy Harvesting Systems**. I²MTC 2008 - IEEE International Instrumentation and Measurement Technology Conference Victoria, Vancouver Island, Canada, May 12-15, 2008

Okel, E.; Schaar, B.; Kanoun, O.: **Simultaneous Measurement of Bulk and Contact Resistance of Conductive Materials for Fuel Cells**. I²MTC 2008 - IEEE International Instrumentation and Measurement Technology Conference Victoria, Vancouver Island, Canada, May 12-15, 2008

Chair Power Electronics and Electromagnetic Compatibility

Contact: Prof. Dr. Prof. h.c. Josef Lutz

Phone: +49 (0)371 531 33618

Email: josef.lutz@etit.tu-chemnitz.de

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. Main working fields:

- Reverse recovery of high power diodes, dynamic avalanche and ruggedness:
  At high stress in dynamic avalanche, current tubes or filaments occur. Of most importance is the nn^+-junction (at y=375µm in Fig. 1). Designs with improved ruggedness are deduced.

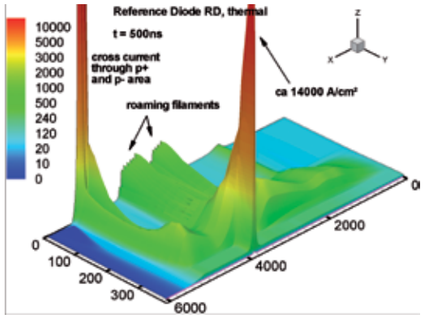


Fig.1: Simulation of current filaments at strong dynamic avalanche. Example of 3.3kV power diode

- Surge current behaviour of power diodes in Si and SiC:
  Metallization thickness and interconnection pitch are of decisive influence. In the middle of the structure in Fig. 2 is a bond foot of 300µm width.

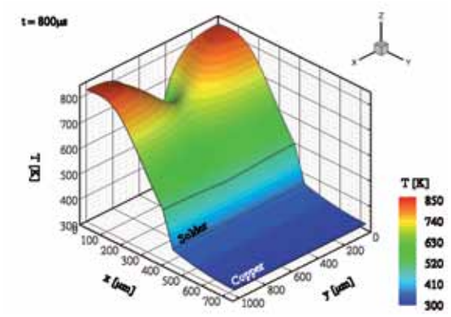


Fig.2: Simulated temperature in a 3.3kV diode after a trapezoidal surge current pulse of 4.5kA/cm²

- Short circuit capability of high voltage IGBTs:
  Measurements, evaluation, analysis

- 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:
  Focus is on power cycling. Six self-build power cycling stations are running. New interconnection technologies for power cycling capability up to 200°C are investigated, Fig. 3.

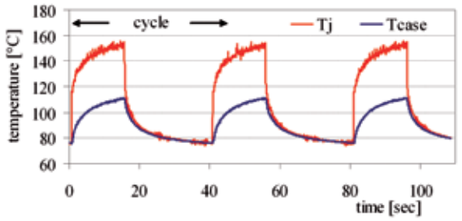


Fig.3: Power cycling: Measured junction temperature T_j and case temperature T_{case}

- Diamond like carbon a-C:H:
  Deposition system with 32cm diameter process area available

- 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.

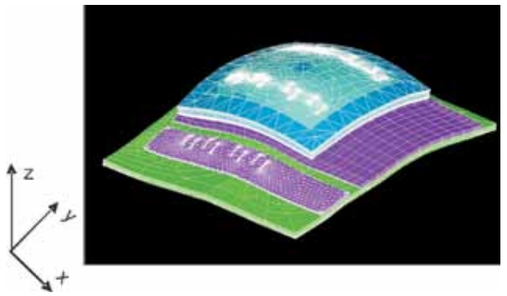


Fig.4: Simulated mechanical deformation of a power device and substrate at power cycling. z-axis 1000x extended.

- DC/DC-Converters for the integration of double-layer capacitors in automotive power-nets:
  Optimized converters for bidirectional power conversion.

Fig.5: Partial integration of the power electronic system in the automobile gear unit (EfA-project). Figure from ZF Friedrichshafen AG

Important research projects

- SiC switching devices in matrix converters:
  Active and passive turn-on and turn-off characteristics, short circuit capability and behavior at paralleling have been investigated. Project finished in 2008.

- 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

Baburske, R.; Heinze, B.; Lutz, J.; Niedernostheide F.-J.: **Charge-carrier Plasma Dynamics during the Reverse-recovery Period in p+-n--n+ diodes**. IEEE Trans El Dev, Vol 55, No 8 (2008), pp. 2164-2172

Heinze, B.; Lutz, J.; Felsl, H.P.; Schulze, H.-J.: **Ruggedness analysis of 3.3 kV high voltage diodes considering various buffer structures and edge terminations.** Microelectronics Journal, Volume 39, Issue 6 (2008), pp. 868-877

Felsl, H.P.; Pfaffenlehner, M.; Schulze, H.; Biermann, J.; Gutt, Th.; Schulze, H.-J.; Chen, M.; Lutz, J.: **The CIBH Diode – Great Improvement for Ruggedness and Softness of High Voltage Diodes**. ISPSD 2008, Orlando, Florida, USA

Heinze, B.; Lutz, J.; Neumeister, M.; Rupp, R.: **Surge Current Ruggedness of Silicon Carbide Schottky- and Merged-PiN-Schottky Diodes**. ISPSD 2008, Orlando, Florida, USA

Bayerer, R.; Licht, T.; Herrmann, T.; Lutz, J.; Feller, M.: **Model for Power Cycling lifetime of IGBT Modules – various factors influencing lifetime**. Proceedings of the 5th International Conference on Integrated Power Electronic Systems, 2008, pp. 37-42, ISBN 978-3-8007-3089-6

Feller, M.; Lutz, J.; Bayerer, R.: **Power Cycling of IGBT-Modules with superimposed thermal cycles**. PCIM Europe 2008, Nuremberg, Germany

Equipment and service offers

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

The ZfM facilities include 1000m² of clean rooms (300m² of them ISO4). Modern equipments were installed for processing of 100 mm, 150 mm and 200 mm 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”
- Electron beam lithography
- Proximity and contact double-side

Characterization and Test:

- MEMS/NEMS
- Nano electronic devices
- Parametric testing: Waferprober, HP Testsystem
- Characterization of analogue-mixed signal circuits up to 500 MHz

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

Processes

- High temperature processes: Diffusion / Thermal oxidation / Annealing / RTP
- PVD (Cr, Au, Ag, Ti, TiN, Ta, TaN, Cu , Pt, Co, Al, W, TiW, $AlSi_x$, CrNi, MoNi, MOFe, Pyrex)
- Chemical vapor deposition CVD (MOCVD, PECVD, LPCVD)
  - » PECVD / LPCVD (SiO_2, Si_3N_4, Polysilicon, $Si_xO_yN_z$, SiCOH, SiCH)
  - » PECVD (diamond-like Carbon films, a-C:H)
  - » Cu-MOCVD, TiN-MOCV
- Electroplating: Cu, Ni, Au
- Etching (dry: Plasma- and RIE-mode & wet: isotropic / anisotropic)
  - » Dry etching (Si, SiO_2, Si_3N_4 Polysilicon, Silicides, Al, refr. metals, TiN, Cr, DLC, low k dielectrics)
  - » Wet etching (SiO_2, Si_3N_4 , Si, Polysilicon, Al, Cr, Au, Pt, Cu, Ti, W)
- Wafer lithography / Electron beam lithography
- Chemical mechanical polishing CMP (Copper, Silicon, SiO_2)

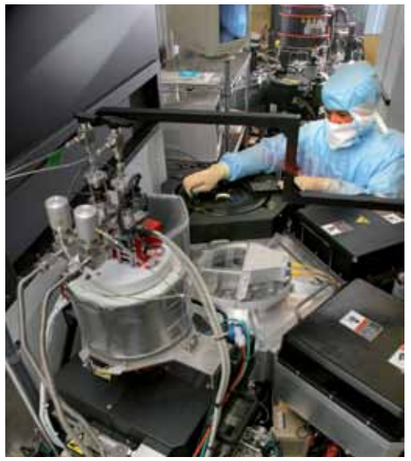


Fig.2: P5000 used for deposition of Copper

Fig.3: Wafer inspection at the microscope

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

Lectures

Chair Microtechnology

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

Interconnect Processes and Technology – Back-end of Line (BEOL) Processing
Lecturers: Prof. Dr. T. Gessner, Prof. Dr. S. E. Schulz

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

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

Reliability
Lecturer: Prof. Dr. B. Michel

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

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

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 Lecturer:
Lecturers: Prof. Dr. J. Mehner, H. Specht

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

Microsystems for Medical Applications
Lecturer: Dr. A. Müller (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

Digital 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.-Ing. J. Horstmann

Electronic Devices
Lecturer: Prof. Dr.-Ing. J. Horstmann

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

Integrated analog Circuit Design
Lecturer: Dr.-Ing. S. Heinz

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

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

Microelectronics
Lecturer: Dr.-Ing. S. Heinz

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

Micro- and Nano Devices
Lecturer: Prof. Dr.-Ing. 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. König

Simulation of Elektroenergetic Systems
Lecturers: Prof. Dr. J. Lutz, Dr. S. König

Chair for Measurement and Sensor Technology

Electric Measurement Technology
Lecturer: Prof. Dr.-Ing. O. Kanoun

Electric Measurement Technology
Lecturer: Prof. Dr.-Ing. N. Kroemer

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

Smart Sensor Systems (English and German)
Lecturer: Prof. Dr.-Ing. O. Kanoun

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

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

Automotive Sensors (English and German)
Lecturer: Prof. Dr.-Ing. O. Kanoun

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

Fundamentals of Technical Optics
Lecturer: Dr.-Ing. M. Arnold

Optoelectronic
Lecturer: Dr.-Ing. M. Arnold

Photonics
Lecturer: Dr.-Ing. M. Arnold

Zentrum für Mikrotechnologien

Contact:
Prof. Dr. Dr. Prof. h.c. mult.
Thomas Gessner
Head of Center for Microtechnologies

Chemnitz University of Technology
Faculty of Electrical Engineering and
Information Technology
Center for Microtechnologies
Reichenhainer Strasse 70
D-09126 Chemnitz

Phone: +49 (0)371 531 24060
Fax: +49 (0)371 531 24069

E-mail: info@zfm.tu-chemnitz.de
http://www.zfm.tu-chemnitz.de