

2 Organization

Center for Microtechnologies

Prof. Dr. Wolfram Dötzel

Prof. Dr. Gunter Ebest

Prof. Dr. Joachim Frühauf

Prof. Dr. Thomas Gessner

Prof. Dr. Dietmar Müller

Prof. Dr. Christian Radehaus

Our scientific research focuses on microsystem technology, microelectronics, as well as optoelectronics and integrated optics. In these fields, the Chemnitz University of Technology has had a tradition and experience of more than 30 years.

The research comprises ULSI metallization technologies, fabrication and application of micromechanical components, modeling, simulation and design of processes, devices, components, circuits and test structures down to the nanometer range, as well as single electron tunneling technologies, nonlinear photonic materials and fiber optics.

In education, the specified and related topics are taught in the basic and main courses. The institute offers the specializations Electronics/Microelectronics, Microsystem/Device Technology and Mechatronics.

The equipment is provided for the institute in combination with the Center for Microtechnologies and comprises a complete silicon wafer line, mask making equipment, commercial software and hardware for simulation and design, as well as extensive analysis and semiconductor measurement technology.

The Center for Microtechnologies facilities include 1000 m² of clean rooms (about 30 % of them class 10 to 100) with equipment for mask and wafer processes.

Visit our WWW page URL: <http://www.infotech.tu-chemnitz.de/~zfm>

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3 Memberships

Prof. Dr. Wolfram Dötzel

Gesellschaft für Mikroelektronik und Mikrotechnik (VDI/VDE-GMM), Fachausschuß
“Trendanalyse”
Member of the Academy of Science of Saxony, Leipzig / Germany
ESPRIT III – Network „NEXUS“
DFG-Fachgutachter „Mikro- und Feinwerktechnik“

Prof. Dr. Gunter Ebest

Vertrauensdozent „Studienstiftung des Deutschen Volkes“

Prof. Dr. Thomas Gessner

Member of „Scientific Advisory Board of the Federal Republic of Germany “
Member of the Academy of Science of Saxony, Leipzig / Germany
Member of “Senatsausschuss Evaluierung der Wissenschaftsgemeinschaft Gottfried Wilhelm Leibnitz” (WGL)
Member of the Board of „KoWi“, Service Partner for European R&D funding, Brussels
The Institute of Electrical and Electronics Engineers, Inc. (IEEE) , USA
The Electrochemical Society, USA
Fraunhofer-Gesellschaft IZM Berlin, Head of Department „Micro Devices and Equipment“
(Branch Lab Chemnitz)
Center of Microfabrication Technology, Saxony , Director
(Zentrum Mikrofabrikationstechnik Sachsen)
„Advisory Professor“ of FUDAN University: honorary professor, 1st June 1999

Prof. Dr. Dietmar Müller

Member of the Academy of Science of Saxony, Leipzig / Germany

Prof. Dr. Christian Radehaus

Optical Society of America (OSA)
The Institute of Electrical and Electronics Engineers, Inc. (IEEE), USA
The American Physical Society (APS)
Deutsche Physikalische Gesellschaft (DPG)

Fraunhofer Institute Reliability and Microintegration
Branchlab Chemnitz
Department: Micro Devices and Equipment



Director: Prof. Thomas Gessner Management: Dr. Thomas Otto

Since 1998 a strong cooperation exists between the Fraunhofer Institute for Reliability and Microintegration (FhG IZM) and the Center for Microtechnologies. Accordingly the new department “Micro Devices and Equipment” (MD&E) was founded to connect the packaging know-how of the FhG IZM with the silicon micromachining products of the Center for Microtechnologies.

In 2002 the department MD&E has moved in new labs inside the Microfabrication Center Saxony (μ Fab). One lab is for Packaging and the other lab for MEMS measurement. The Packaging lab is re-equipped with the following equipment:

CMP, cleaner, die and wafer bonder, dicer and special measurement technique.

The lab for MEMS measurement is also new equipped with a wafer prober for MEMS, signal network analyzer, optical measurement systems (monochromator, radiometry system, ...) and electrical measurement equipment.

The research activities of the department MD&E are focussed on the following fields:

- *Development of MEMS*, for example sensors (kinetic, pressure, force, chemical) and actuators (scanner) to systems
- *Development of advanced technologies* (3D-patterning – deep silicon etching, chip and wafer bonding including combinations of new materials)
- *Process and equipment simulation* (The goal is the improvement of deposition and etch rates, uniformity and fill behavior of vias and trenches by optimizing process conditions and reactor design.)

One main task of the new assembly technologies development is the combination of silicon micromechanics with down scaled traditional precision mechanics, which allows new devices and new low cost fabrication technologies.

To reach this goal, a strategic alliance between the Fraunhofer Institute for Reliability and Microintegration, Department MD&E (Prof. Gessner), the Fraunhofer Institute Machine Tools and Forming Technology, Department for Microfabrication (Prof. Neugebauer, Prof. Schubert), and ZEBRAS (Prof. Matthes) was established. The result is the Microfabrication Center Saxony (μ Fab), which allows strong synergies in the technology development.

Nano-Technology Center of Excellence "Ultrathin Functional Films"

The Center of Excellence "Ultrathin Functional Films" (UFF), distinguished by the Federal Ministry of Research (BMBF) as a nation-wide center, is coordinated by Fraunhofer-IWS Dresden. It joins 38 enterprises, 14 university institutes, 19 research institutes, and 6 corporations into a common network. Nano-technology is one of the key technologies of the 21st century. In order to channel the research results already available at institutes and universities as well as the growing demand from industry, the Nano-Technology Centers of Excellence (CE) had been established in 1998. The Center for Microtechnologies is an active member within this center, especially in the field of microelectronics related topics.

Contact: Office of Center of Excellence "Ultrathin Functional Films"
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Activities within the frame of Nano-CE-UFF are subdivided into 6 Working Groups (WG), every one of which 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 actotics and sensorics

The Working Groups, in which the Center for Microtechnologies is mainly involved, are described shortly in the following:

Advanced CMOS

Structural widths of about 200nm are state-of-the-art in CMOS technology. A reduction down to below 100nm within 10 years, for further miniaturization, is envisaged by the Semiconductor Roadmap (by Semiconductor Industry Association (SIA) and SEMATECH). Along with this trend, higher frequency and reliability are required. This implies novel developments in materials and processes for both the active elements and the interconnect system, including advanced equipment for larger Si-wafer production. Most present-day systems are made of contacts (e.g. titanium or cobalt silicide), barrier layers (TiN, TiW), isolating interlayers (SiO₂), interlayer connections and conducting paths (Al-alloys). Copper with its high conductivity and stability with respect to electromigration is being introduced as conductor material leading to higher frequency and reliability. This requires a precise technology of copper deposition (aspect ratio > 3) and patterning and the availability of suitable barrier layers suppressing interdiffusion and reactions. The barrier layers must not affect the conductivity of the paths remarkably, which requires ultra-thin films. Interfaces and nanometer scale effects become increasingly important.

Head of the Working Group: Prof. Dr. Thomas Gessner (Chemnitz University of Technology)

Novel components

The continuing trend towards miniaturization of integrated circuits has given rise to increasing efforts to supplement and gradually replace conventional CMOS-technologies by nano-technologies and nano-electronics in near future. The latter include magneto-electronics,

and single-electron devices, nano-cluster storage elements, and resonant tunneling elements, among others.

There is a new generation of novel components based on the transfer of individual electrons in nano-scale structures. Work centers on memory elements based on the transfer of individual electrons between metal electrodes and on the memory effect of semiconductor nano-clusters in SiO₂ films.

Head of the Working Group: Prof. Dr. J. Fink

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Microfabrication Center μ Fab Saxony / Chemnitz

At the end of 1998 the Microfabrication Center Saxony was founded by three institutions: Fraunhofer Institute for Machine Tools and Forming Technology (IWU Chemnitz), Fraunhofer Institute for Reliability and Microintegration (IZM Berlin, Branchlab Chemnitz) and "ZEBRAS e.V." Institute in Chemnitz.

Prof. Neugebauer, Prof. Gessner and Prof. Matthes are on the managing board of the Center, respectively. Prof. Thomas Gessner ist the Center Manager.

The goal of this initiative is to synergise the expertise of the three partners for cost effective fabrication of Micro Electro Mechanical Systems (MEMS). One example is the fabrication of MEMS and systems based on silicon technology combined with down scaled precision mechanical components.

In 2002 all departments of the Microfabrication Center Saxony moved to a complete new reconstructed building inside the Fraunhofer Institute for Machine Tools and Forming Technology. The building offers best conditions by a lot of new labs and offices.

The center specializes in the following fields:

- Microfabrication technologies (alternative microfabrication techniques, development of plant techniques, micro tool making, micro embossing)
- Measurement techniques for MEMS
- Development of MEMS; advanced Assembly Technologies, for example wafer bonding technologies
- Process- and Equipmentsimulation for CVD, PVD and etching
- Micro welding techniques
- Development of equipment for the fabrication of MEMS

4 Research activities of ZfM in cooperation with the FhG-IZM-branchlab Chemnitz

Fields of research

- Design and fabrication of microelectrical and micromechanical elements and arrays
- ULSI metallization
- High temperature stable metallization
- Analysis of micromechanical systems
- Development and application of design tools and methods for micromechanical components and systems & coupled field analysis
- Experimental analysis of microsystems
- Analysis of different interferences on micromechanical systems, reduction or compensation of these interferences
- Coupling of microsystems and instrumentation (mechanical, electrical, thermal and substantial interfaces)
- Function, principles and modelling of electronic devices (test structures, parameter extraction, model building)
- Microelectronic circuit design (read out- and controlling circuits for sensors and actuators)
- MIS – solar cells (manufacturing, analysis, measuring and modelling) & multicrystalline solar cells
- Electronics for micro-electromechanical systems (MEMS)
- Design of reusable modules
- Development of infrared measurement systems
- Nanoelectronics
- Integrated Optics
- Colour measurement

Subjects of research

- Microfabricated scanner arrays
- Electrostatically driven torsion actuators with one or two DOF
- High temperature applications of MEMS, e.g. gas sensor for exhaust measurement
- Vibration monitoring based on Si-sensor arrays
- Sensor / actuator systems for high precision scanning with a large vertical range
- Transportation systems by using MEMS-actuators
- Gyroscopes
- Simulation of micromechanical and microelectrical components, materials databases
- Design tools for microsystems and microelectronics
- Macromodels for simulation of micromechanical components using PSpice
- Design and fabrication of integrated optical waveguides on silicon
- Fiber-optical communication systems
- Single Electron Tunnelling Technologies
- Colour measurement and sensors
- Orientation dependent etching of silicon: Development of etchants and determination of etch rates, design of etch masks and simulation of etch process, development of new structures by multi-step etch processes
- Geometrical measurement on microstructures

- Plastic deformation of silicon-microstructures
- Copper metallization
- Low k dielectrics
- Equipment and process simulation for microelectronics
- Development of probing equipment for 1/f measurements
- Microwave Device and Circuit Design and Simulation
- Reliability analyses

4.1 Current research projects

BMBF Project „Perfect“

Project Manager: Prof. T. Gessner
 Project Leader: Chemnitz University of Technology
 Partners: Infineon Technologies AG Munich, DaimlerChrysler AG Ulm,
 Dresden University of Technology, University of Hannover
 Project duration: 01.11.2000 - 31.10.2003
 Project goal: Application of Copper interconnects for mobile communication IC's,
 power devices and micrometer wave devices; Integration of organic
 low k dielectrics into Copper Damascene metallization

BMBF Project „Ultradünne Barrieren“

Project Manager: Prof. T. Gessner
 Project Leader: Chemnitz University of Technology
 Partners: AMD Saxony Manufacturing GmbH Dresden, Dresden University of
 Technology, Institut für Festkörper- und Werkstoffforschung Dresden
 Project duration: 01.08.2000 - 31.07.2003
 Project goal: Process development and characterization of ultrathin diffusion barriers

BMBF Project „Nanoporöse SiO₂ - Schichten“

Project Manager: Prof. T. Gessner
 Project Leader: Applied Materials GmbH
 Partners: Applied Materials GmbH, Suss Microtec AG Vaihingen
 Project duration: 01.10.2000 - 30.09.2002
 Project goal: Development of prototype equipment for deposition of porous silicon
 oxide low k dielectrics; Process optimization and film characterization

BMBF Project „IPQ (IP Qualification)“

Project Manager: Prof. D. Müller
 Project duration: 01.07.2001 - 31.12.2003
 Project goal: The methodologies and tools developed in the project IPQ are targeted on
 significant improvements in quality assurance in the development and ap-
 plication of Intellectual Property (IP). This includes the development of
 new methods for IP specification, intelligent IP retrieval, techniques for
 (semi)automatic IP adaptation as well as contributions to IP standardisati-
 on activities.

BMBF Project „Integrierter busfähiger Anzünder“

Project Manager: Prof. T. Gessner
Project Leader: Chemnitz University of Technology
Partners: TEMIC microelectronics Nürnberg, TRW Airbag systems Aschau/Inn
NICO Pyrotechnik Trittau, Dynamit Nobel Fürth
Project duration: 01.01.2000 - 31.12.2002

BMW Projekt „Optimization of the multicrystalline solar cell process by means of RTP and RIE“

Project manager: Prof. G. Ebest
Partners: RWE Schott Solar, Alzenau
Project duration: 01. 04. 2001 – 31. 03. 2004
Project goal: Proof of rapid thermal processing and reactive ion etching for solar cell fabrication

BMBF Project „Electronic compensation of fabrication tolerances of microsystem products demonstrated for a multi sensor for navigation (EKOFEM)“

Project Manager: Prof. T. Gessner
Partners: LITEF GmbH Freiburg, GEMAC mbh Chemnitz, FhG IZM, Department Chemnitz
Project duration: 01. 10. 2001 – 31. 12. 2004
Project goal: Development of electronic compensation methods of fabrication tolerances and their application for a high precision silicon multisensor (acceleration and angular rate measurement)

SMWA Project „Spectral tunable infrared sensor“

Project Manager: Prof. T. Gessner
Partners: InfraTec GmbH Dresden, FhG IZM, Department Chemnitz
Project duration: 01. 01. 2001 – 31. 03. 2003
Project goal: Development of layout and technology for a micromachined Fabry-Perot-Interferometer for IR applications; Fabrication of prototypes

SMWA Project „Entwicklung mikromechanischer Spiegel für ein IR-Analysesystem“

Project Manager: Prof. T. Gessner
Partners: FhG IZM Abteilung Micro Devices and Equipment
COLOUR CONTROL Farbmeßtechnik GmbH
OPTUM Umwelttechnik GmbH
Project duration: 01.01.2001 – 31.12.2002
Project goal: Development of an IR-Spectrometer with a micromechanical mirror with a special reflective grating on the mirror surface

SMWA Project „VIBSENS: Abstimmbares frequenzselektives Sensorsystem zur Messung mechanischer Schwingungen“

Project Manager: Prof. T. Gessner
Partners: GEMAC mbh Chemnitz
Project duration: 01. 01. 2002 – 31. 12. 2003

DFG Project "Reshaping of silicon microstructures by Laser – a new micro-technological process"

Project Manager: Prof. J. Frühauf
Partner: HTW Mittweida
Project duration: 04.09.2000 – 03.09.2003
Project goal: Reshaping without tool, minimizing of thermal load, development of new shapes

EU-Project "ULISSE : Ultra low k dielectrics for Damascene copper interconnects schemes"

Project Manager: Prof. T. Gessner
Partners: Infineon Technologies, Philips, IMEC, ST Microelectronics, Bull, LETI Grenoble
Project duration: 01.10.2001 – 31.08.2003
Project goal: Integration of ultra low k dielectrics

EU-Project Intelligent Manufacturing Systems: "Optical Characterisation Methods for MEMS Manufacturing - OCMMM"

Project Manager: Prof. T. Gessner
Partners: GF Messtechnik GmbH (GFM), FhG.IWU, University of Twente-MESA, Thales Avionique (TH-AV), Yole Développement (YOLE), LioniX (LION), Warsaw University of Technology (WUT)
Project duration: 01. 01. 2001 – 31. 12. 2003
Project goal: Optical Characterisation Methods for MEMS Manufacturing

Industrial Research Contract „Fabrication of multi-use acceleration sensors“

Project Manager: Prof. T. Gessner
Partners: Fara New Technologies, Xi'an, China, GEMAC mbH Chemnitz
Project duration: 01. 09. 2001 – 31. 08. 2003
Project goal: Development of an high precision acceleration sensor system and its fabrication technology; Fabrication of prototypes

Stiftung Industrieforschung : „Catalogue of Shape and Functional Elements of Bulk-Silicon Microtechnique“

Project Manager: Prof. Dr. J. Frühauf
Project duration: 01. 04. 2002 – 31. 05. 2003
Project goal: Systematical description of shapes and functions realisable by anisotropic wet etching

Project „Design of complex sensor – actuator systems [EKOSAS]“

Project Manager: Prof. W. Dötzel, Dr. J. Mehner
Partner: Siemens AG Munich, CAD-FEM GmbH Grafing, GEMAC mbH Chemnitz, AST Dresden, Univ. Erlangen, FhG IIS/EAS Dresden
Project duration: 01. 01. 2000 – 31. 03. 2003
Project goal: The goal of the project is to develop methods and tools for modeling and simulation of complex microelectromechanical systems which are characterized by strong interactions between physical domains and to the electronic circuitry.

DFG Project „VIVA – Low Power System Bus Encoding“

Project Manager: Prof. D. Müller
Project duration: 01.07.1999 - 31.03.2003
Project goal: Development and implementation of coder-decoder systems for SoC system busses which minimize under a set of constraints the total power dissipation on a system bus with its coder and decoder implementation through reduction of switching activity on this bus.

Project „Detection of gear faults using microsystems“

Project Manager: Prof. D. Müller
Project duration: 01.11.2001 - 31.10.2002
Partner: TU Dresden
Project goal: Development of a small hardware system for gear monitoring – Gear monitoring systems are used to detect gear faults. Today's systems are expensive and need much space. In order to decrease the system costs a space- saving hardware system was developed and tested.

Project „Interface-based Design of complex digital Systems“

Project Manager: Prof. D. Müller
Project duration: 01.07.1999 - 31.03.2003
Project goal: The focus of this project are the development of methods for modelling communication between modules of highly complex systems at different levels of abstraction in terms of hierarchically layered data communication protocols and the realization of corresponding description formalisms as an extension of the language SystemC.

Service order for master agreement research and development, entered by AMD and Technische Universität Chemnitz

Project Manager: Prof. C. Radehaus
Project duration: 1.5. 2001 - 30.04. 2002
Project goal: Development of a Software-Package for Evaluation of a CM (VG, f)- and GM (VG, f)-Curves measured by Gate-Voltage (VG) and Small-Signal Frequency (f) using P- and N-Channel Capacitors

Pesticide-Sensors based on Immunochemical Reactions and Nano-Electrodes

Project Manager: Prof. C. Radehaus
Project duration: 1.3. 2001 - 31.8. 2002
Project goal: Study of feasibility of Pesticide-Sensors based on Immunochemical Reactions and Nano-Electrodes

Project: "Entwicklung von Packagingtechnologien für Bauelemente in Oberflächen-technologie"

Project Manager: M. Krusche, Amtec GmbH
Partners: FhG IWU, TU Chemnitz, Gemac GmbH, Amtec GmbH
Project duration: 05/2002 – 04/2004
Project goal: MEMS packaging for surface micro machined devices

4.2 Collaborative Research Center No. 379 :
(Sonderforschungsbereich SFB Nr. 379)
01. 01. 1995 – 31. 12. 2003

„Arrays of micromechanical sensors and actuators“

The MEMS research field covers several provinces using different microtechnology methods for the fabrication.

The subject of the SFB deals with the well-defined part of the microsystems research:

“The realization of sensor and actuator arrays consisting of a number of single components”.

Thus, results concerning the behavior and new application fields of the devices would be expected. As a vision of the future it is aimed toward a system which combines the arrays with the electronics by microtechnology integration.

Within the focus of interest are the following topics:

- Micromechanical scanning devices (actuators fabricated in bulk and surface micromachining)
- Use of micromechanical basic components, e.g. for ultrasonic arrays and positioning systems, including the application of new materials
- Developing further a SCREAM-based Technology

The following institutions are working together

Faculty of Electrical Engineering and Information Technology

Chair Circuit Technology, Prof. Dr. Reinald Brumme, Prof. Dr. Rainer Barthel

Chair Microsystems and Precision Engineering, Prof. Dr. Wolfram Dötzel

Chair Electronic Devices, Prof. Dr. Gunter Ebest

Group Material Science, Prof. Dr. Joachim Frühauf

Chair Microtechnology, Prof. Dr. Thomas Gessner

Chair Measurement and Sensor Technology, Prof. Dr. Wolfgang Manthey

Chair Circuit and System Design, Prof. Dr. Dietmar Müller

Chair Optoelectronics & Solid-State Electronics, Prof. Dr. Christian Radehaus

Faculty of Natural Science

Chair Semiconductor Physics, Prof. Dr. Dietrich R. T. Zahn

Faculty of Mechanical Engineering and Process Technology

Chair Production Technology, Prof. Dr. Michael Dietzsch

Fraunhofer Institute „Reliability and Microintegration“, Branchlab Chemnitz

Head of the Institute: Prof. Dr. Bernd Michel

Institut für Mechatronik e.V. Chemnitz, Prof. Dr. Peter Maißer