Msc. Microsystems Engineering - Introduction to the programme

Prof. Dr. Jürgen Wilde

15 October 2019

The technology

A macrosystem

The Airbus A380

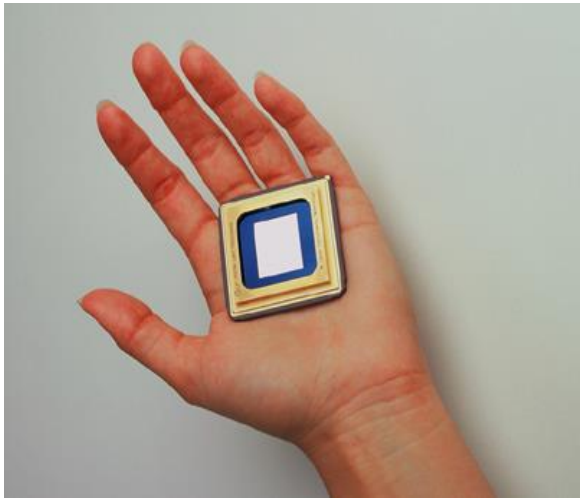
- Approximately 1 Million single parts!
  - One Wing: 32,000 parts
- Costs: $ 275 Millions
  - Average per single part $ 275
- High effort for single part fabrication

Can you imagine such a system with 2 Million parts?

A microsystem

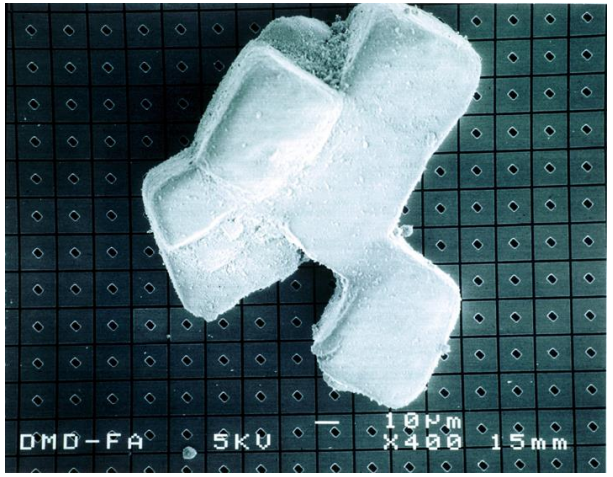
The DMD

- Digital Micro-mirror Device
- 1.6 cm x 1.6 cm
- 508,800 mirrors 17 µm x 24 µm
- ~ 2.2 million parts
- Price: ~ € 2 000
- Price / part: < 0.1 Cent
- Mass fabrications

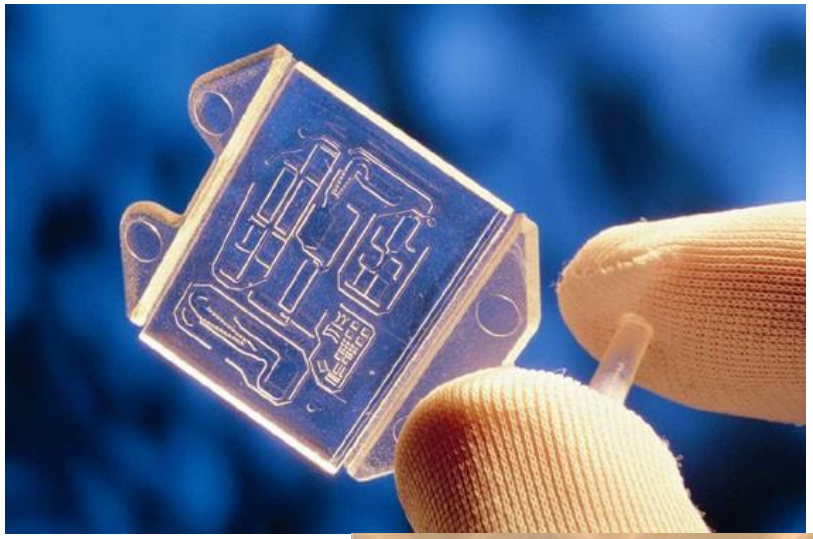


Microsystems

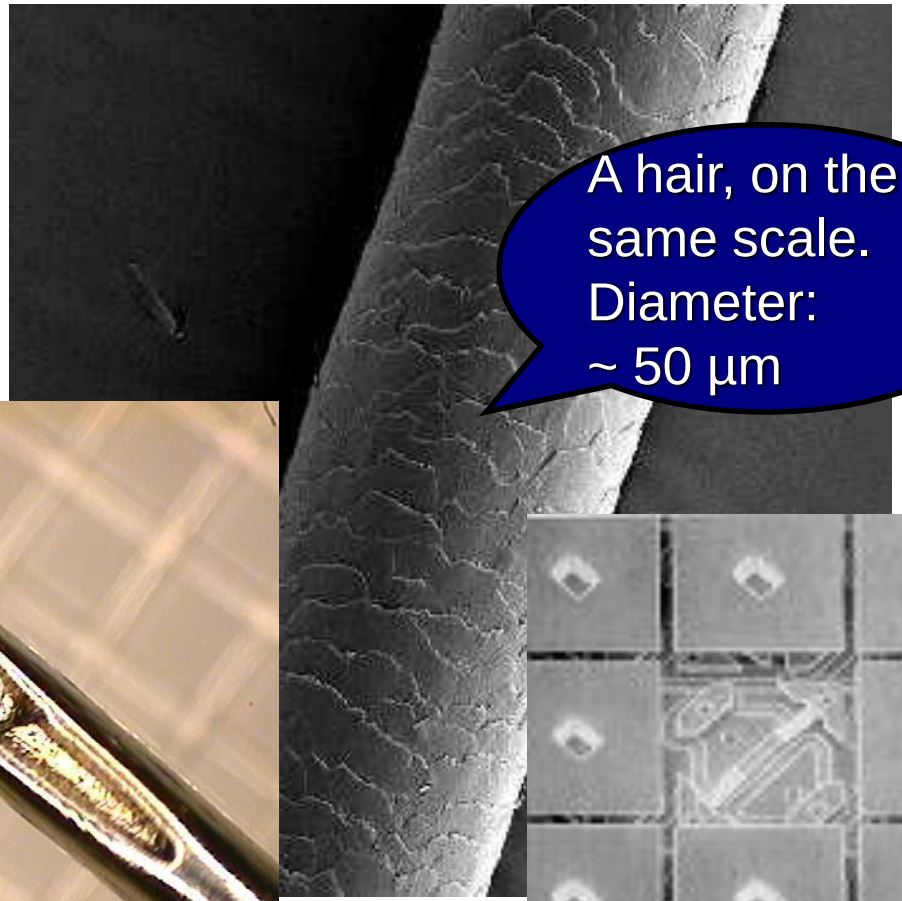
- Many functions
- Small volume



Microsystems are small



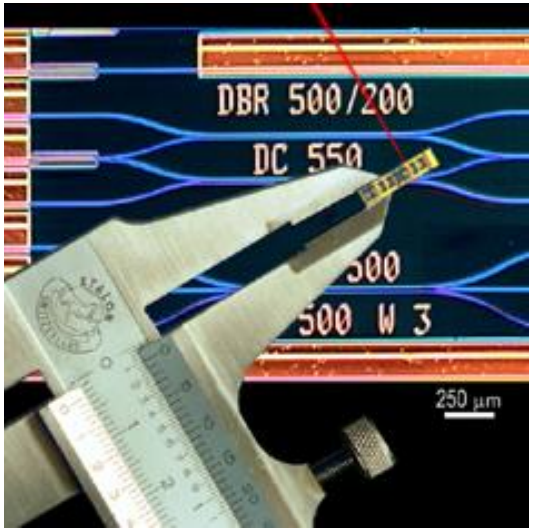
Small

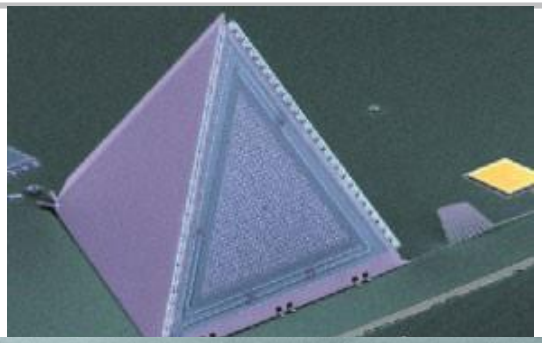


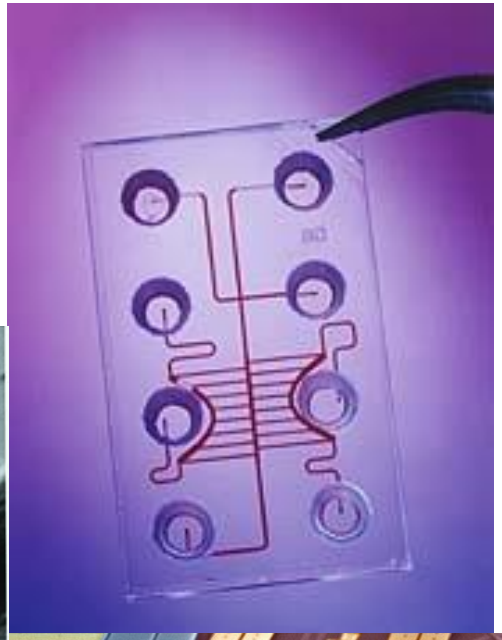
Smaller

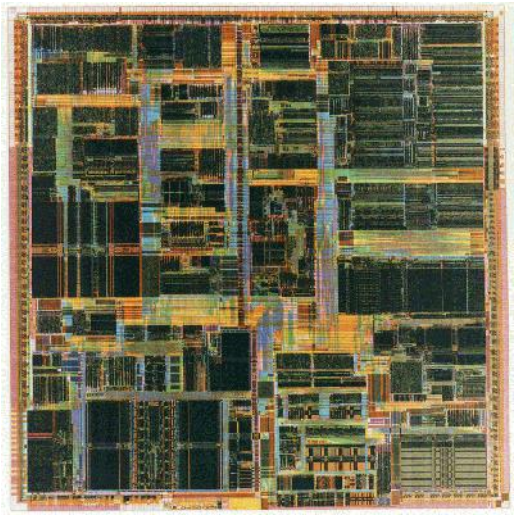
Tiny

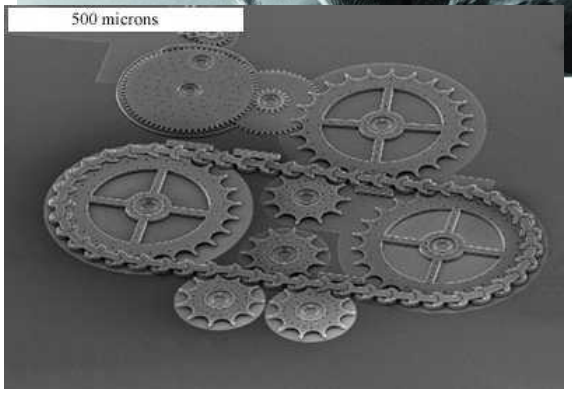
A huge variety in microsystems

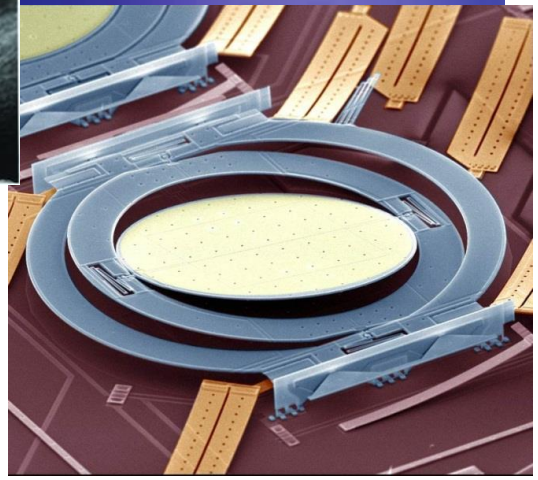






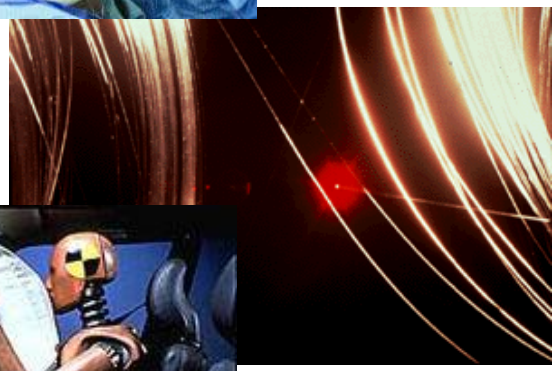






Microsystems are everywhere

- **Medicine**
  - Minimally-invasive surgery
  - Diagnostics
- **Communications**
  - Fiber optics
  - Mobile phones
- **Consumer**
  - Autonomous networks
  - Sensors
- **Industry**
  - Process management
  - Instrumentation
- **Automobile**
  - Rotatio rate sensors
  - Airbags

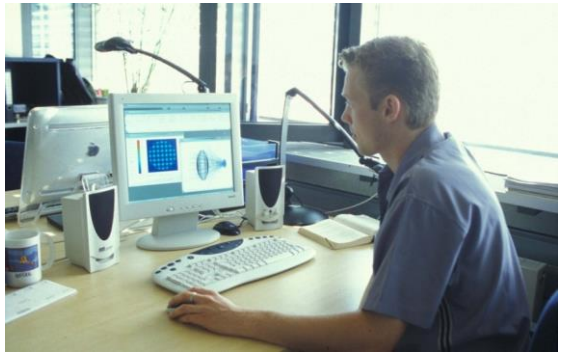


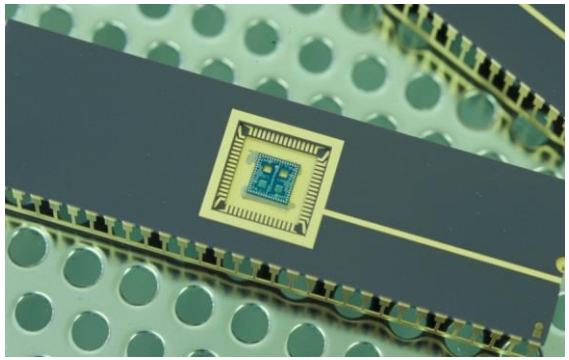
The career

Studies: technical skills

- **Educational goal:**
  - To graduate students who can go from idea to product
- **The required skills:**
  - Problem definition
  - Solutions & evaluation
- **Design & development**
  - Fabrication
  - Characterization & optimization
  - Packaging
  - System testing & qualification
  - Transfer to production
  - Marketing

The challenge starts now





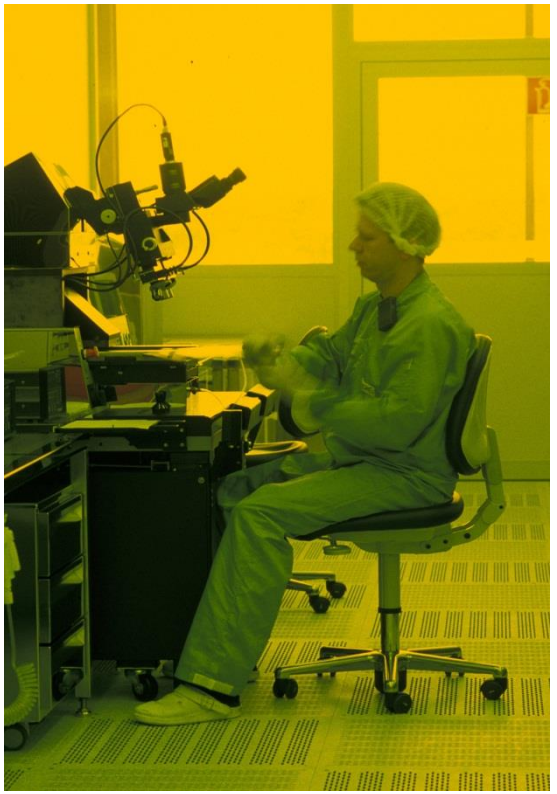
Studies: Non-technical skills

- Technical excellence is a given...

- ... but graduates also need:
  - Ability to work in a team
  - Social competence
  - Creativity
  - Openness to new ideas
  - Self-confidence
  - Communication skills
  - Entrepreneurial thinking
  - Ability to motivate, oneself and others
  - Leadership capabilities

Where do I go with my degree?

- **Microsystems engineers become:**
  - Entrepreneurs, technicians, engineers, group leaders, managers, CEOs, astronauts,…
- **Potential employers:**
  - Large & small companies of all types
  - Startups and spin-offs
- **What do employers want?**
  - Potential for development
  - Ability to learn
  - Communications ability (in English **and** German!)
  - Experience, experience, experience
  - Particular skills? Not so much…



The department

Faculty of Engineering

- Faculty in operation since 1995
- Department of Computer Science (IIF)
  - 19 professors / ~ 820 students
- Department of Microsystems Engineering (IMTEK)
  - 22 professors / ~ 785 students
- Department of Sustainable Systems Engineering (INATECH)
  - 7 professors / ~ 158 students

IMTEK-Professors

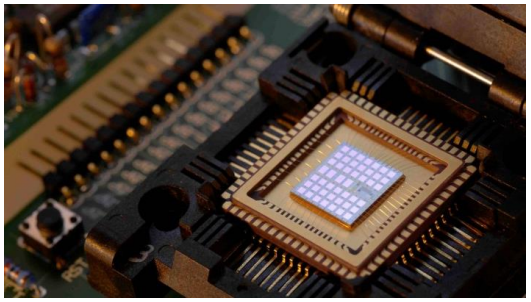
IMTEK Laboratories

- **MEMS Applications**
  Prof. Dr. Roland Zengerle
- **Assembly and Packaging Technology**
  Prof. Dr. Jürgen Wilde
- **Bio- and Nano-Photonics**
  Prof. Dr. Alexander Rohrbach
- **Biomedical Microtechnology**
  Prof. Dr. Thomas Stieglitz
- **Biomicrotechnology**
  Prof. Dr. Ulrich Egert
- **Chemistry and Physics of Interfaces**
  Prof. Dr. Jürgen Rühe
- **Design of Microsystems**
  Prof. Dr. Peter Woias
- **Electrical Instrumentation**
  Prof. Dr. Leonhard Michael Reindl
- **Gas Sensors**
  Prof. Dr. Juergen Woellenstein
- **Materials Process Technology**
  Prof. Dr. Thomas Hanemann
- **Micro- and Material Mechanics**
- **Prof. Dr. Christoph Eberl**

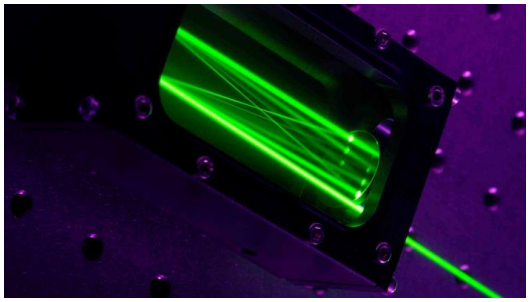
Microactuators
Prof. Dr. Ulrike Wallrabe
Microelectronics
Prof. Dr. Yiannos Manoli
Micro-optics
Prof. Dr. Hans Zappe
Microsystems Materials
Prof. Dr. Oliver Paul
Nanotechnology
Prof. Dr. Margit Zacharias
Optical Systems
Prof. Dr. Carsten Buse
Sensors
Prof. Dr. Gerald Urban
Simulation
Prof. Dr. Lars Pastewka
Smart Systems Integration
Prof. Dr. Alfons Dehé
Systems Theory
Prof. Dr. Moritz Diehl
Process Technology
Prof. Dr. Bastian E. Rapp

Our foci in research and teaching

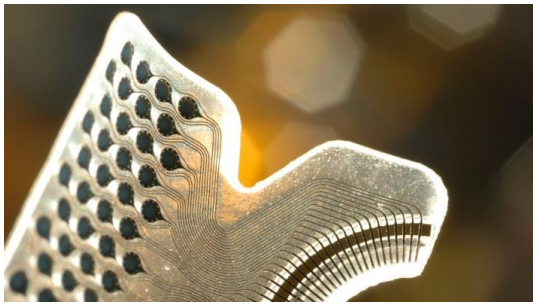
- Circuits and Systems
- Design and Simulation
- Biomedical engineering
- Lab-on-a-chip
- Materials
- Photonics
- Process Engineering
- Sensors and Actuators



Chip integrated fuel cell



Optical gas sensor



Electrode array for the brain

The curriculum

Microsystems Engg. education

General principles:

- Interdisciplinary basic education
  in electrical engineering, physics, chemistry, materials science, technology
- Hands-on education
  lab classes in the clean room, electronics and chemistry lab classes, system design project...

- Systems and application oriented
  education with a broad, encompassing view
- Fit for business - non-technical education:
  project management, IP, business plans, company financing...

Microsystems Engg. education

Structural principles of all study programs at the faculty

- 30 ECTS per semester
- 30 hours work load per credit point
- All programs are organized in modules
- A module can consist of one or several courses
- Performance evaluation after the semester

Modules in the study program

- **Module Components**
  - Lectures – German: Vorlesung (V)
  - Exercises – German: Übung (Ü)
  - Laboratories – German: Praktikum (Pr) oder Praktische Übung (PrÜ)
- **Pass/fail assessments (“Studienleistungen”)**
  - Exercises, reports, mid-term exams…
  - Are not part of your final grade, but may be part of a module (for example the exercise sheets)
  - Are not always graded (only “pass” or “fail”)
- **Graded assessments (“Prüfungsleistungen”)**
  - Written or oral exams, reports, …
  - Are always graded

MSc. program in Microsystems

Scope of MSE

- Feasible in 4 semesters (average duration 6 semesters)
- 120 ECTS

Components

- Mandatory courses
- Concentrations (elective courses)
- MSc thesis

Educational goals

- Research qualification
- Laboratory techniques
- Presentation & reporting capability

MSE – Mandatory modules

Module	Semester	Type	ECTS
Advanced Microsystems Engineering	**All modules to be completed**		**53**
Microelectronics	1	VÜ	5
Micro-mechanics	1	VÜ	5
MST Design Lab I	1	P	3
Micro-optics	1	VÜ	5
Sensors	1	V+P	5
MST Technologies and Processes	1	VÜ	5
Signal Processing	2	VÜ	5
Assembly and Packaging Tech.	2	VÜ	5
Biomedical Microsystems	2	VÜ	5
Micro-actuators	2	VÜ	5
Micro-fluidics	2	VÜ	5
Mathematics	This module to be completed		**5**
Probability and Statistics	1	VÜ	5

MSE – Elective modules

Module	Semester	Type	ECTS
2 concentration areas to be chosen. At least 9 ECTS in each of them. Total ECTS required 32			
Circuits and Systems	2-4		
Design and Simulation	2-4		
Life Sciences: Biomedical Engineering	2-4		
Life Sciences: Lab-on-a-chip	2-4		
Materials	2-4		
MEMS Processing	2-4		
Photonics	2-4		
Sensors and Actuators	2-4		
Personal Profile	2-4		
Master‘s thesis (mandatory)	3-4		30
Total	1-4		120

MSE – Elective modules

Circuits and systems	Design and Simulation
Energy Storage and Conversion using Fuel Cells	Embedded Control Laboratory
Mixed Signal CMOS Circuit Design	Flight Control Laboratory
Advanced embedded Systems Laboratory	Modelling and System Identification
Advanced Laboratory in Microcontroller	Numerical Optimisation
Power Electronics: Devices and Concepts	Numerical Optimisation Software Project
Magnetic Microsystems	Numerical Optimal Control in Science and Engg.
Embedded Control Project	Optimal Control and Estimation
Microcontroller Techniques	Optimal and Model Predictive Control
Power Electronic Circuits and Devices	Race Car Control Lab
RF- and Microwave Devices and Circuits	VLSI System Design
RF- and Microwave Systems Design course	Wind Energy Systems
Systems Theory and automatic Control II	
Reliability Engineering	

MSE – Elective modules

Life Sciences: Biomedical Engg.	Life Sciences: Lab-on-a-chip
Analyse von Life Science Hochdurchsatzdaten mit Galaxy	Bioactive Polymer Surfaces
Selected Problems in Biosignal Processing	Biofuel Cells and Bioelectrochemical Systems
Biofunctional Materials - for medical microsystems and healthcare	BioMEMS
Biologie für Ingenieure	Biotechnology for Engineers I: Introduction, Molecular- and Microbiology
Bionic Sensors - Laboratory	Biotechnology for Engineers II
Biomedical Instrumentation I	Interfaces for Bioanalytical Systems
Biomedical Instrumentation II	Introduction to data driven life sciences
Biomedical Instrumentation - Laboratory	Basics in Molecular Biology for Bioanalytical Systems
Biophysics of the cell	Microfluidics II: Miniaturize, automate and parallelize biochemical analysis
Ethical Aspects of Neurotechnology	Surface Analysis
Fundamentals of electrical stimulation	
Introduction to physiological Control Systems	
Implant Manufacturing Technologies	
Signal processing and analysis in brain signals	
Microsystems technology in Medicine	
Nanobiotechnology	
Neurophysiology - Laboratory	
Neuroprosthetics	
Neuroscience for Engineers	

MSE – Elective modules

Materials	MEMS Processing
Bioactive Polymer Surfaces	Lithography
Bioactive Polymer Surfaces with seminar	Electrochemical production technologies
Bioinspired functional materials	CMOS-Integrated Microsystems
Computational physics: materials science	Advanced Assembly and Packaging Technology
Electrochemical Energy Applications: Batteries	Lithography
Semiconductor Technology and Devices	Advanced Silicon Technology
Ceramic Materials for microsystems	Micro-Acoustical Transducers
Ceramic technology in microsystems	Microstructured Polymer Components
Physics of Failure	Mold Flow Simulation for Replication Processes
Contact, Adhesion, Friction	Nanotechnology
Continuum Mechanics I with exercises	Advanced Engineering
Continuum Mechanics II with exercises	Surface Analysis Laboratory
Mechanical Properties and Degradation Mechanisms	Silicon-based Neural Technology
Molecular Statics and Dynamics	Surface coating Techniques
Nanomaterials	
Nano - Laboratory	
Particle Methods in Engineering	
Surface Analysis	
Polymer Chemistry for Engineers	
Polymers in Membrane Technology	
From Microsystems to the Nanoworld	
Dynamics of Materials	

MSE – Elective modules

Photonics	Sensors and Actuators
Advanced Topics in Micro-Optics	Thin Film Analyses and Nanoscale Measurement Technologies
Lasers	Bionic Sensors
Basic Optics Lab	Wireless Sensor Networks
Basic and Advanced Optics Lab	Wireless Sensor Systems
Optical Materials	Disposable sensors
Optical Properties of Micro and Nano Structures	Electrochemical energy applications: Li-ion batteries and fuel cells
Optical Trapping and Particle Tracking	Energy harvesting
Optical MEMS	Gas Sensors
Optical Measurement Techniques	Power Electronics for E-Mobility
Optical Micro-Sensors	Electrochemical Methods for Engineers
Optoelectronics	Mikroaktorik für Mikrosystemtechniker
Photonic Microscopy	Microacoustics
Photovoltaic Energy Conversion for engineers	Piezoelectric and dieelectric transducers
Photovoltaic Energy Conversion for engineers II	Quantum mechanics for engineers
Spektroskopische Methoden	Electronics Signal Processing for Sensors and Actuators
Wave Optics	Thermoelektrik
	Compound semiconductor devices

MSE courses, first semester

Mon	Tue	Wed	Thu	Fri
	08:00 - 10:00 Probability and Statistics lecture Room 101 01 009/013	08:00-10:00 Probability and Statistics, tutorial Room 101 01 009/013	8:00 – 10:00 Microelectronics tutorial Room 082 00 006	
10:00 – 12:00 Micromechanics Lecture Room 101 00 026		10:00-12:00 Microelectronics lecture Room 082 00 006	10:00 - 12:00 Micro-optics lecture Room 101 00 010/014	10:00-12:00 Micromechanics tutorial Room 101 01 009/013
	13:00 – 14:00 MST Technologies and Processes, tutorial Room 101 00 026		13:00 - 14:00 Sensors Lecture Room 101 01-009/013	12:00 - 14:00 MST Design Lab I Room 082 00 006
	14:00 – 16:00 Sensors Lecture Room 101 01-009/013		14:00 – 16:00 MST Technologies and Processes, lecture Room 101 00 026	14:00 – 16:00 Micro-optics tutorial Room 051 00 034 Room 051 00 006
	16:00 – 18:00 MST Design Lab I Lecture Room 082 00 006		16:00 – 18:00 Sensors Lab, group 1 Room 078 00 035	16:00 – 18:00 Sensors Lab, group 4 Room 078 00 035
			18:00 – 20:00 Sensors Lab, group 2 Room 078 00 035	

Plagiarism

- Plagiarism is:
  - Using someone else's texts, pictures, reports, data, solutions, whatever….
  - ... without giving the **source**
- Sources include:
  - Books, the internet, colleagues, …
- To make it clear:
  - Plagiarism is illegal
- The simple „if...then" loops:
  - If you plagiarize...(once)
  - … then you fail
  - If you plagiarize repeatedly (=twice)
  - … then your academic career is over.

Some thoughts to share…

- **A Master‘ program in Germany**
  - You have to organize your courses and your life
  - Make sure to observe the deadlines for course and exam registration
  - We challenge you from the first day on to assess given knowledge…
  - …and to transfer given knowledge from one course to another
  - We will show you many aspects of microsystems related disciplines and applications to broaden your knowledge and increase the oppurtunites for an exciting career.
- **That means for you…**
  - YOU have to take the initiative to ASK, ASK and read until you understand
  - WE give you the overview, YOU have to learn the details

The art of living

Enjoy being a student!

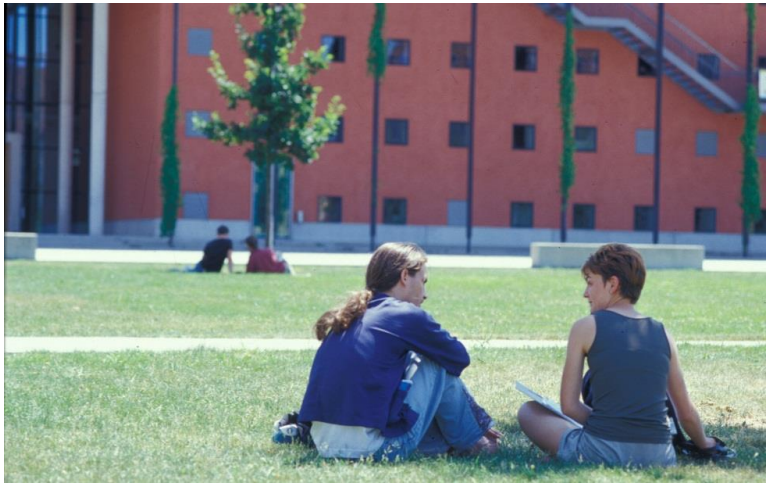
- It is helpful to
- Structure your day
- Have unstructured free time
- Meet colleagues
- Keep up with your work
- Turn off on occasion

Don‘t forget

- Family
- Friends
- Sports
- Culture
- Autumn leaves…

Moreover…

- Buy textbooks
- Contact your mentor
- Form study groups
- Poke around in the laboratories
- Find an MSc thesis advisor early
- Stay registered
- Get enough sleep
  - But not in my class, please



Mentoring

- **Every student has a faculty mentor**
  - A professor as a contact person
  - Assigned by the Dean of Studies
- **Student's contact for:**
  - Problems, questions, clarifications, job searches, recommendations, or just general advising

After graduation

Apply for a job

- **In Industry**
  - Find out what you like during your MSc program
  - Use job portals and company websites to monitor the market
  - Visit career workshops to gather tips how to apply
  - Go to recruiting fairs

Phd. as research assistant

- Perform a research project (on your own)
- Look for an open position
- Apply
- Get paid for the PhD project
- Overtake responsibility as project assistant
- Support your professor with respect to educational tasks
- Duration: 3-5 years

Contact persons I

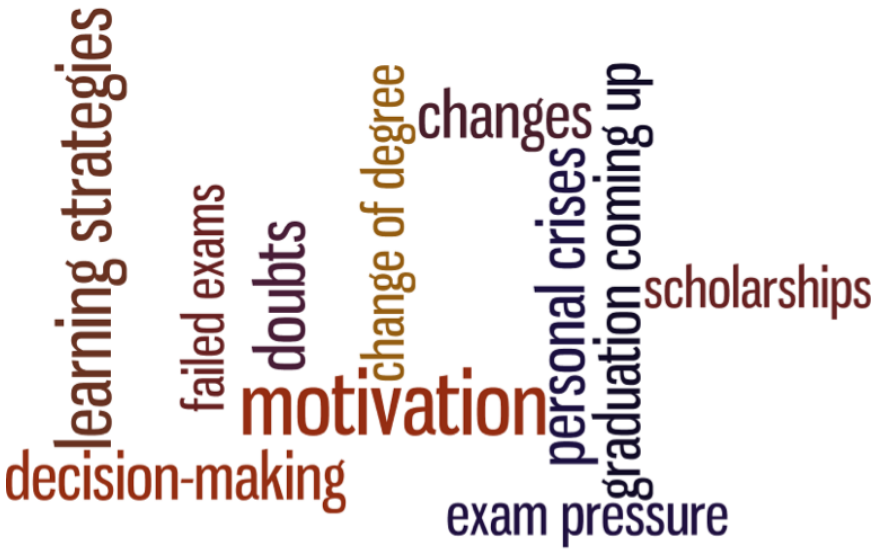
- **Dean of studies:** Prof. Moritz Diehl
  - Moritz.diehl@imtek.de
  - 203 67852
- **Program coordinator:** Ursula Epe
  - studienkoordination@tf.uni-freiburg.de
  - 203 8340
- **Student advisers:**
  - studienberatung@imtek.de
  - Dr. Andreas Greiner
  - 203 67479
  - Dr. Oswald Prucker
  - 203 7164

Contact persons II

- **Examination office**
  - Anne-Julchen Müller
    - pruefungsamt@tf.uni-freiburg.de
    - 203 8083

  - Susanne Storck
    - pruefungsamt@tf.uni-freiburg.de
    - 203 8083

Advising@Service Center Studium



International Admissions and Services (IAS) and Central Academic Advising (ZSB) at Service Center Studium is your first resort for all information and advice concerning your studies

at Sedanstr. 6 (b/n library and theatre)

ZSB / IAS @ SCS

Information

Clearing / first information

- Where to go to …?
- Whom to talk to if…?
- How do I…?
- daily info desk

Hotline
0761 / 203-4246

Advising

…on any topic concerning your studies

- confidential
- impartial
- professional
- open and scheduled consultation hours

Workshops

Smalls groups (mostly in German), topics such as:

- Doubts / hard choices
- Dealing with (study) stress
- Time and self-management
- Masters degree or job search?

www.zsb.uni-freiburg.de www.ias.uni-freiburg.de

Thank you very much for your attention !