Msc. Microsystems Engineering - Introduction to the programme

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The technology

A macrosystem

The Airbus A380

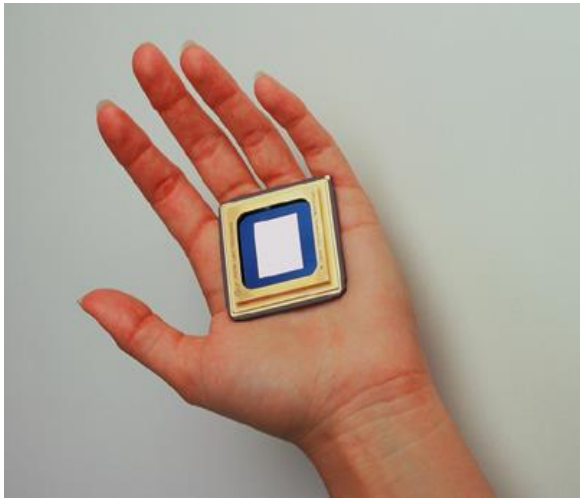
- Approximately 1 Million single parts!
  - One Wing: 32,000 parts
- Costs: $ 275 Millions
  - Average per single part $ 275
- High effort for single part fabrication

Can you imagine such a system with 2 Million parts?

A microsystem

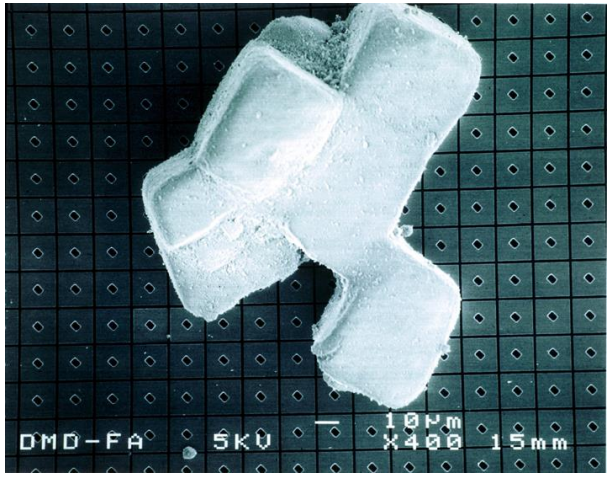
The DMD

- 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

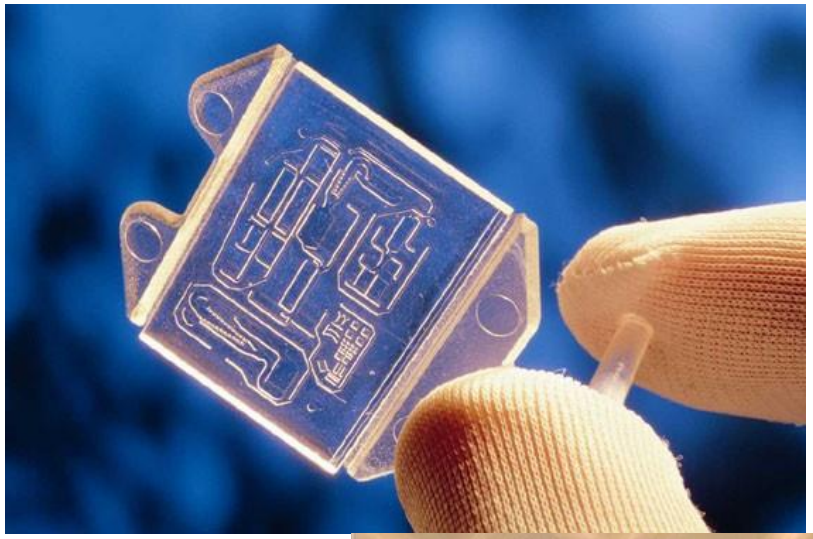


Microsystems

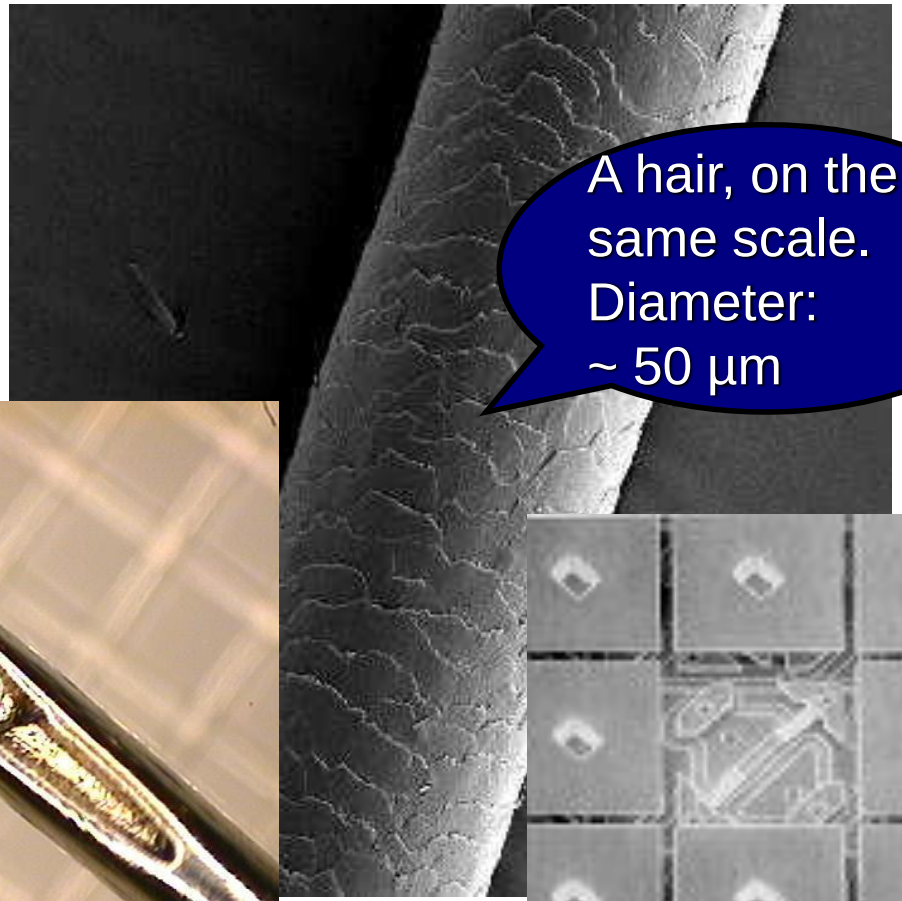
- Many functions
- Small volume



Microsystems are small



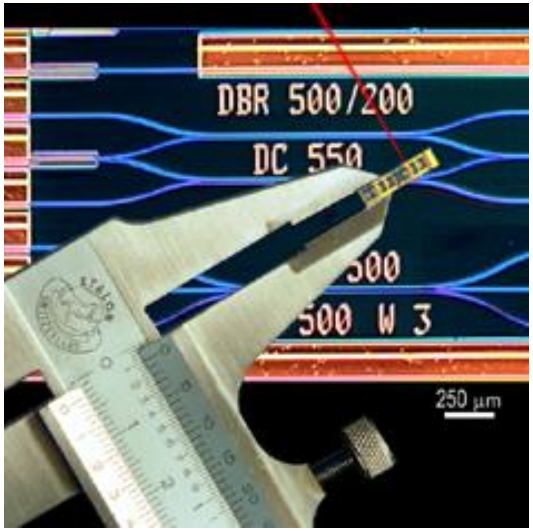
Small

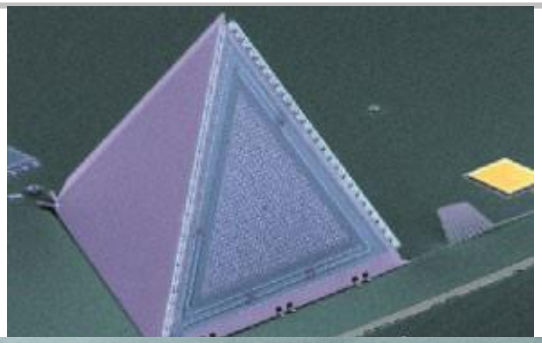


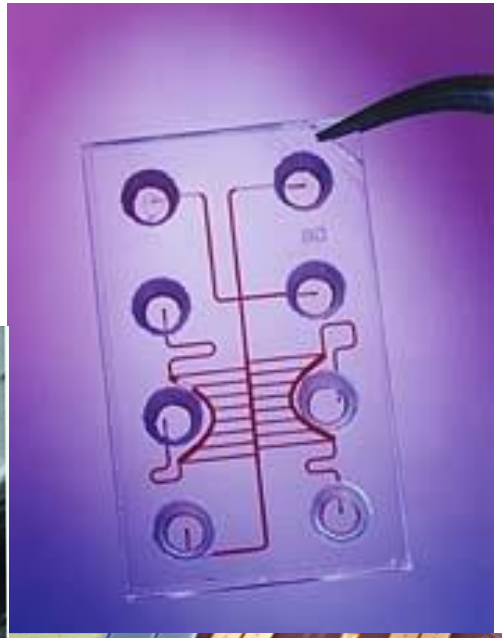
Smaller

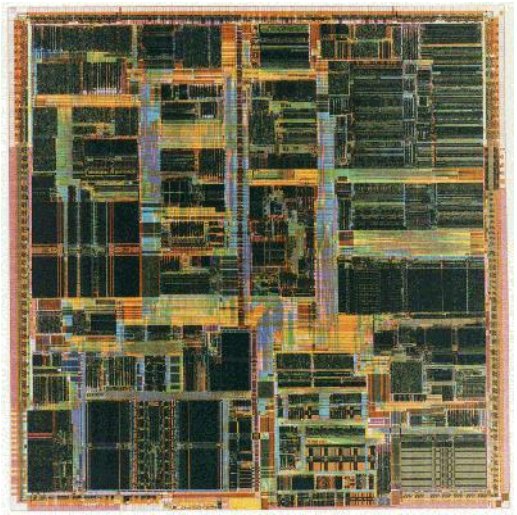
Tiny

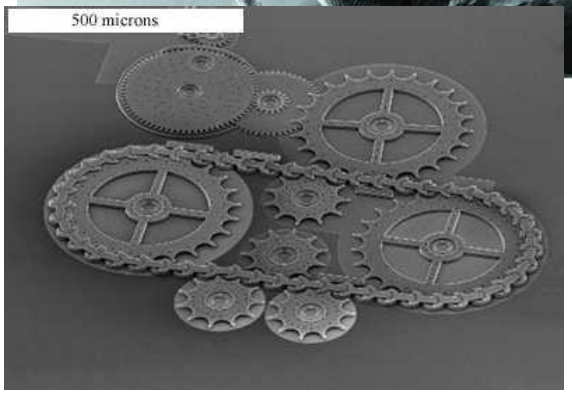
A huge variety in microsystems

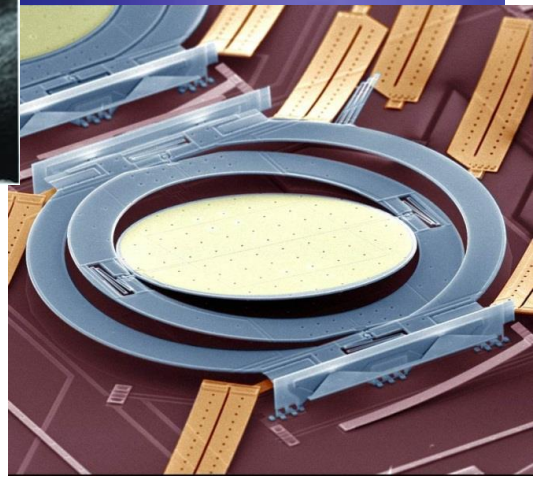






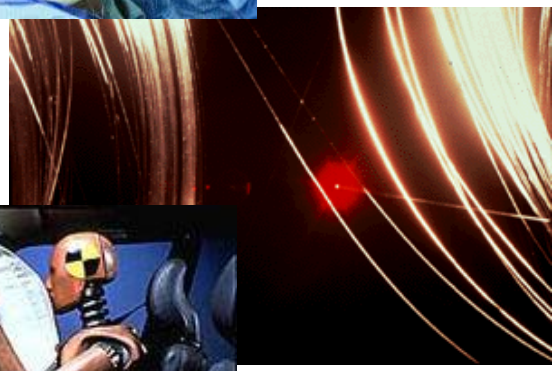






Microsystems are everywhere

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

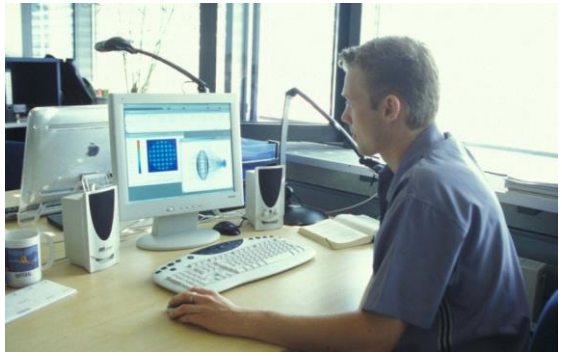


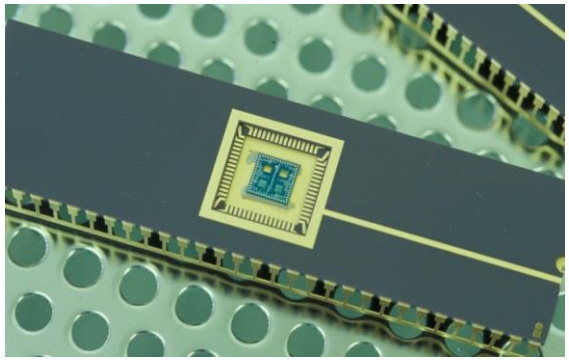
The career

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



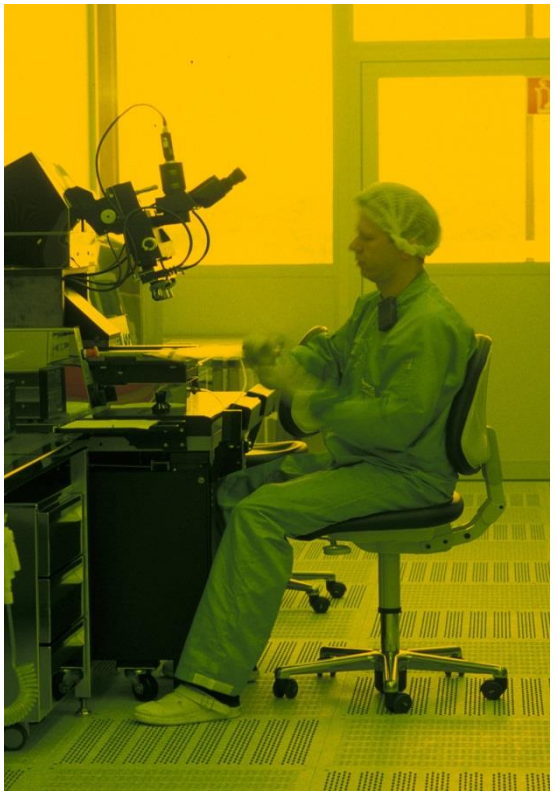


Studies: Non-technical skills

- 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)
  - 18 professors / ~ 800 students
- Department of Microsystems Engineering (IMTEK)
  - 21 professors / ~ 750 students
- Department of Sustainable Systems Engineering (INATECH)
  - 7 professors / ~ 150 students

IMTEK Professors

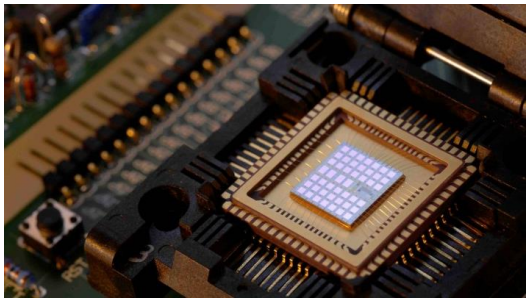
22 Laboratories at IMTEK

- **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

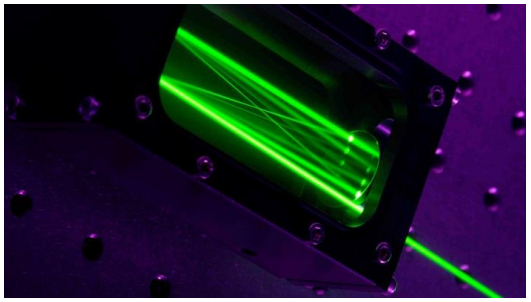
Micro- and Material Mechanics
Prof. Dr. Christoph Eberl
Microactuators
Prof. Dr. Ulrike Wallrabe
Microelectronics
Prof. Dr. Yiannos Manoli
Micro-optics
Prof. Dr. Hans Zappe
Microsystems Materials
Prof. Dr. Oliver Paul
Nanotechnology
Prof. Dr. Margit Zacharias
Optical Systems
Prof. Dr. Carsten Buse
Sensors
Prof. Dr. Gerald Urban
Simulation
Prof. Dr. Lars Pastewka
Smart Systems Integration
Prof. Dr. Alfons Dehé
Systems Theory
Prof. Dr. Moritz Diehl

Our foci in research and teaching

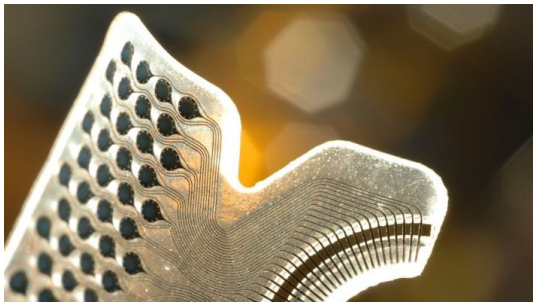
- Circuits and Systems
- Design and Simulation
- Biomedical engineering
- Lab-on-a-chip
- Materials
- Photonics
- Process Engineering
- Sensors and Actuators



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: 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 5 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 and MST joint concentrations

Examples of courses offered in the concentration areas (may vary from year to year)

Module	ECTS
Circuits and systems	
Analog CMOS circuit design	3
Autonomous microsystems	3
Circuit design for sensors and actuators	3
Innovative energy systems	3
Integrated microsystems	3
Optical microsystems	3
VLSI system design	3
Wireless technologies	3
Dynamics of MEMS	3
Design and simulation	
CAD	3
Control of embedded systems	3
Design of large-scale MST systems	3
FEM simulation	3
Multi-scale simulation	3
Quantum mechanics for MEMS	3
Reliability	3
Systems theory II	3

Module	ECTS
Materials	
Atomic force microscopy	3
Biomaterials	3
Ceramics for MST	3
Materials testing and analysis	3
Nanostructured optical surfaces	3
Nanotechnology	3
Polymers for MST	3
MEMS processing	
Advanced silicon technology	3
Applications of LIGA	3
Ceramics laboratory	3
Lithography	3
Low-cost micromachining	3
Microstructured polymer components	3
Thermal microsystems	3

MSE and MST joint concentrations

Life sciences: Biomedical engineering	
Biomedical engineering I (electrical signals)	3
Biomedical engineering II (non-electrical signals)	3
Biomedical measurements and instrumentation lab	3
Biomedical microtechnology	3
Biotelemetry and health telematics	3
Fundamentals of electrical stimulation	3
Implant fabrication technology	3
MST in medicine	3

Life sciences: Lab-on-a-chip	
Analytics with microsystems	3
Bio-MEMS	3
Computational fluid dynamics	3
DNA analytics	3
Micro process engineering	3
Microfluidic platforms	3
Molecular simulation	3

Personal Profile	
Courses from any of the concentration areas	3

Sensors and actuators	
Applications of micro-actuators	3
Bionic sensors	3
Lasers	3
Micro-acoustics	3
Micro-mechanical sensors	3
Optical micro-sensors	3
Position sensors	3
Sensors laboratory	3

Photonics	
Basic Optics Laboratory	3
Basic and Advanced Optics Laboratory	3
Advanced topics in Micro-Optics	3
Micro-optics Laboratory I and II	3
Modern Optics I and II	3
Nonlinear optical materials	3
Optical Materials	3
Optical Trapping and Partikel Tracking	3
Optical measurement techniques	3
Optoelectronic Devices	3
Photonic imaging	3
Wave and Fourier Optics	3

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 101 00 036		
10:00 – 12:00 Micromechanics Lecture Room 101 00 014		10:00-12:00 Microelectronics lecture Room 101 00 036	10:00 - 12:00 Micro-optics lecture Room 101 00 036	10:00-12:00 Micromechanics tutorial Room 101 00 014	
13:00 – 14:00 MST Technologies and Processes, tutorial Room 101 00 026	13:00 – 14:00 Sensors Lecture Room 101 00 010/014		12:00 - 14:00 Micro-optics tutorial Room 101 00 014 Room 101 01 016	12:00 - 14:00 MST Design Lab I Room 082 00 006	
14:00 – 16:00 Sensors Lecture Room 101 00-010/014			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	14:00 – 16:00 Sensors Lab, group 3 Room 078 00 035
	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
  - You have to register for your courses on your own
  - 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

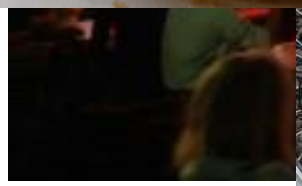
The art of living

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

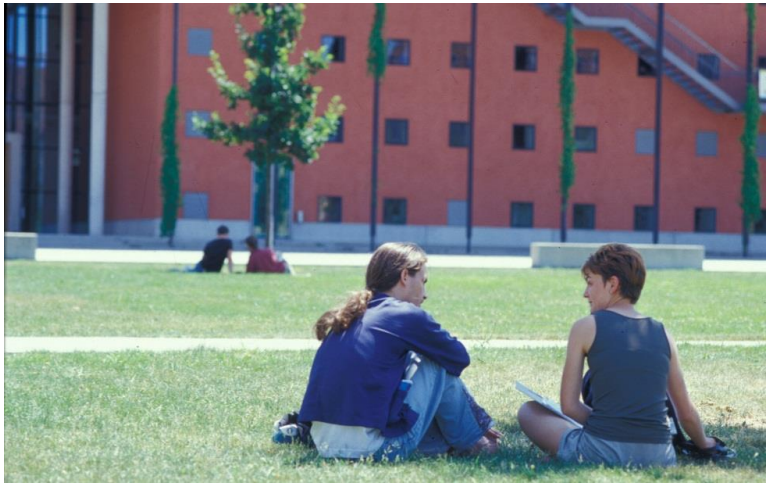
Don‘t forget

- 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:**
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    - 203 67479
  - Dr. Oswald Prucker
    - 203 7164
  - studienberatung@imtek.de

Contact persons II

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

Thank you very much for your attention !