Msc. Microsystems Engineering - Introduction to the programme

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30 October 2020

The technology

A macrosystem

The Airbus A380

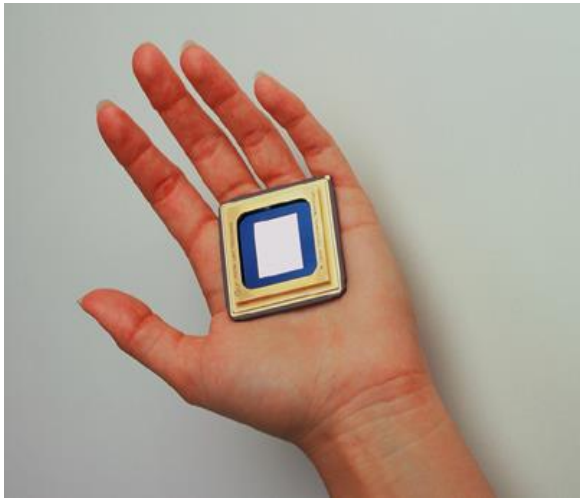
- Approximately 1 Million single parts!
  - One Wing: 32,000 parts
- Costs: $ 275 Millions
  - Average per single part $ 275
- High effort for single part fabrication

Can you imagine such a system with 2 Million parts?

A microsystem

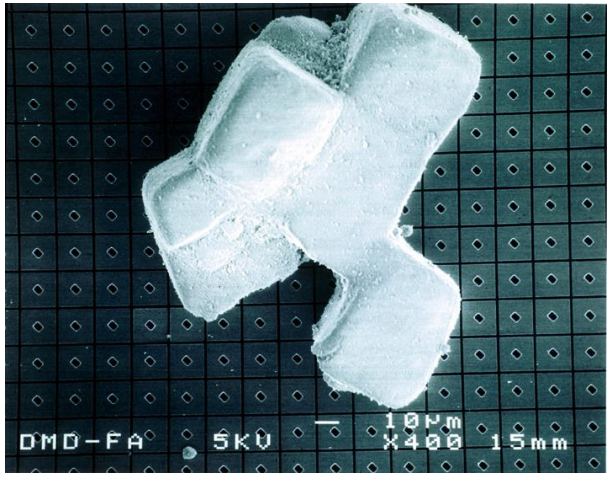
The DMD

- 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

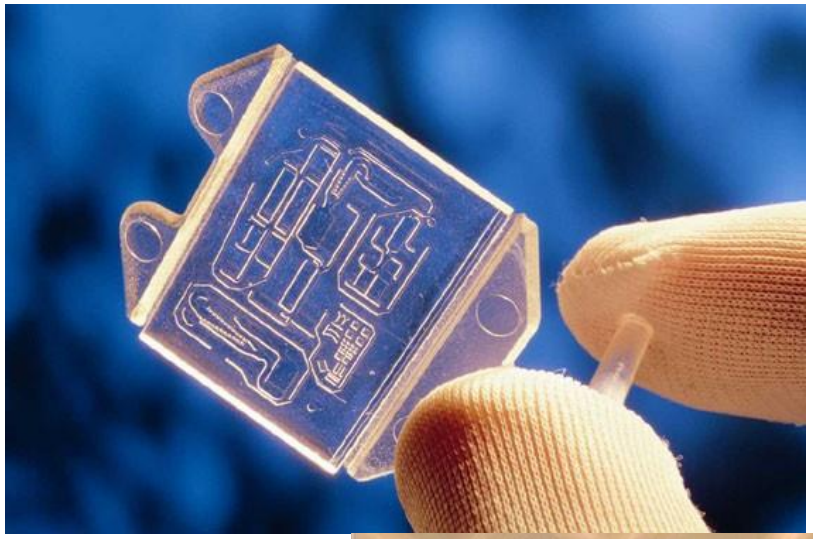


Microsystems

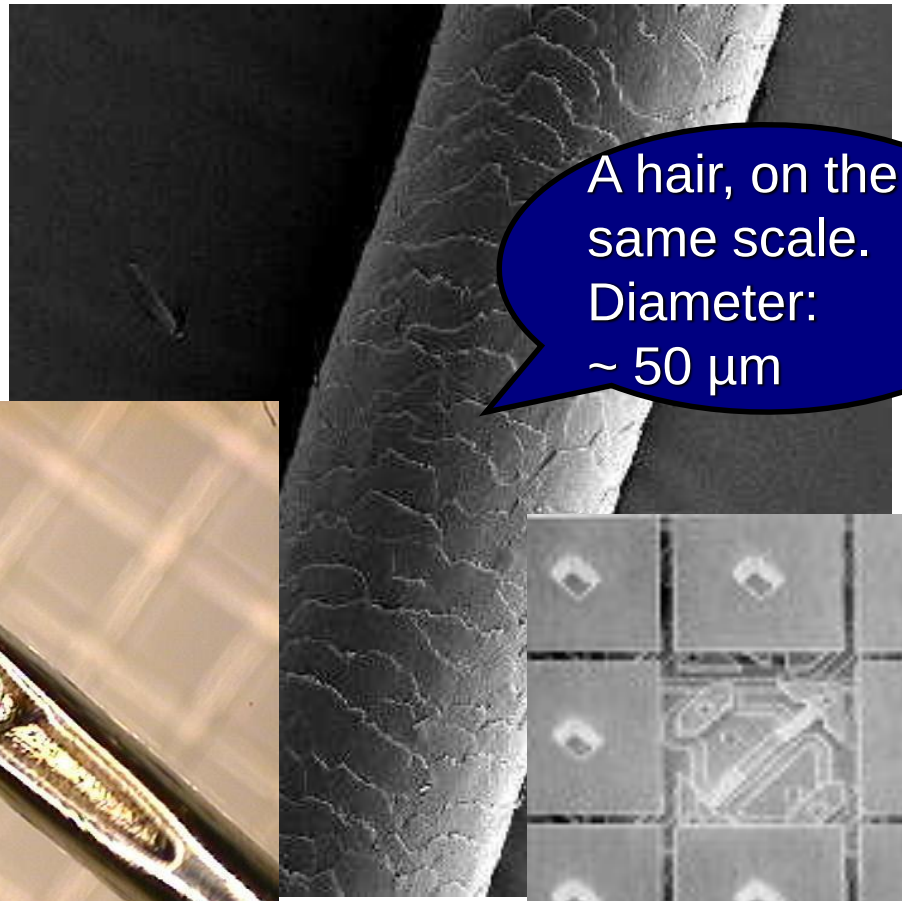
- Many functions
- Small volume



Microsystems are small



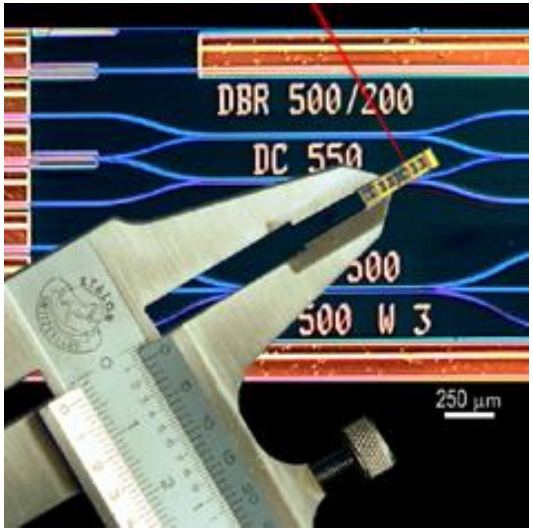
Small

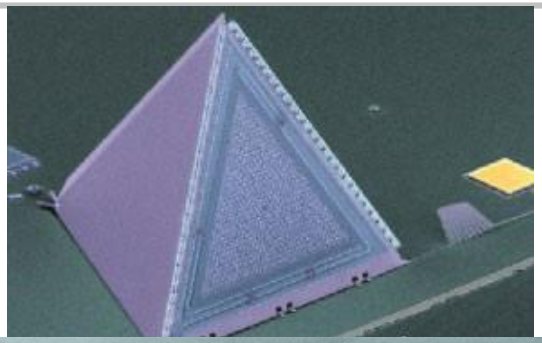


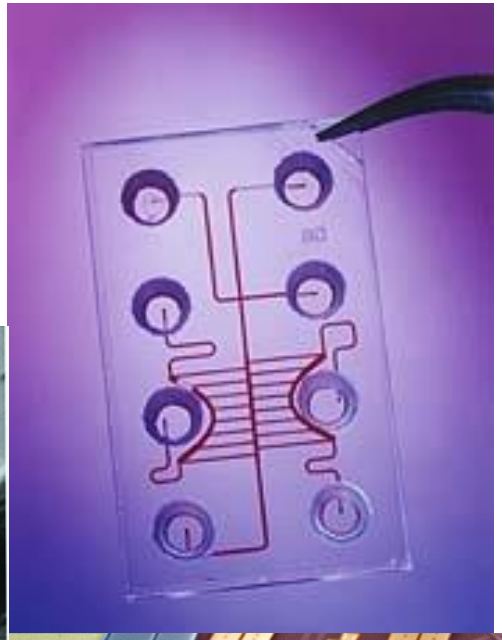
Smaller

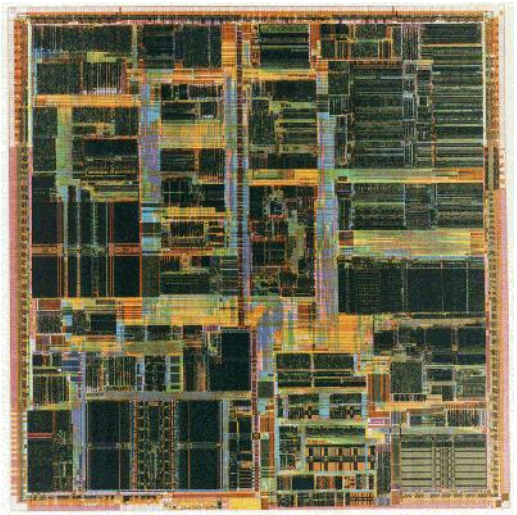
Tiny

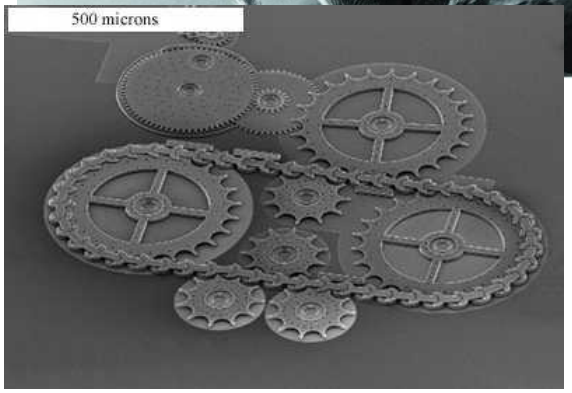
A huge variety in microsystems

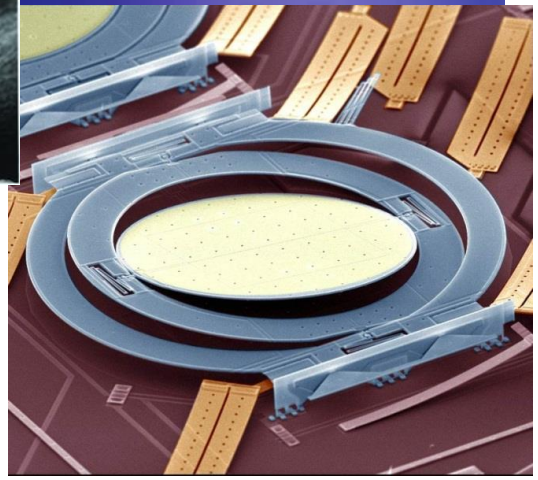






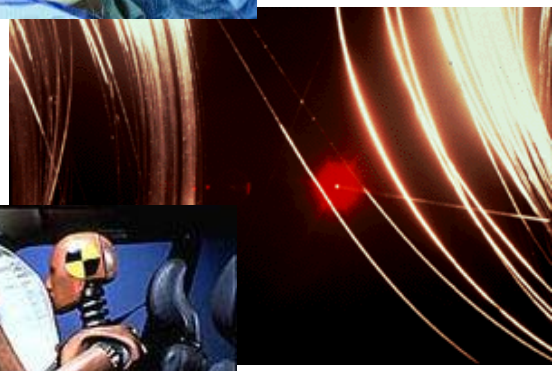






Microsystems are everywhere

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

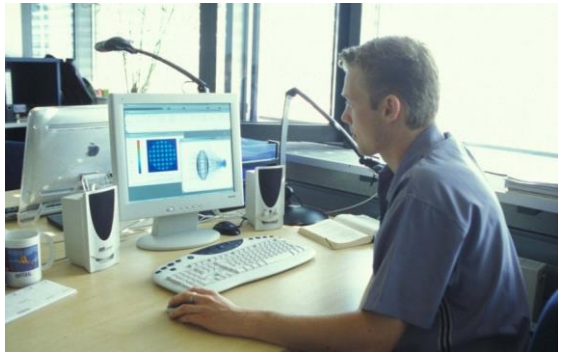


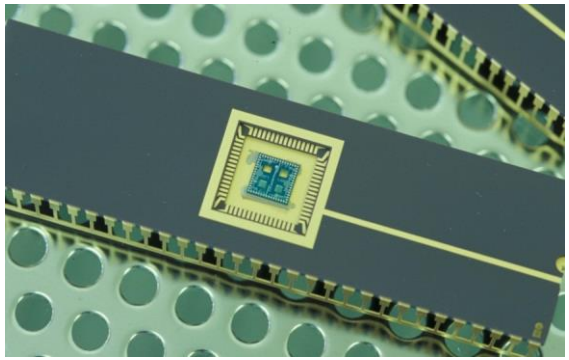
The career

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



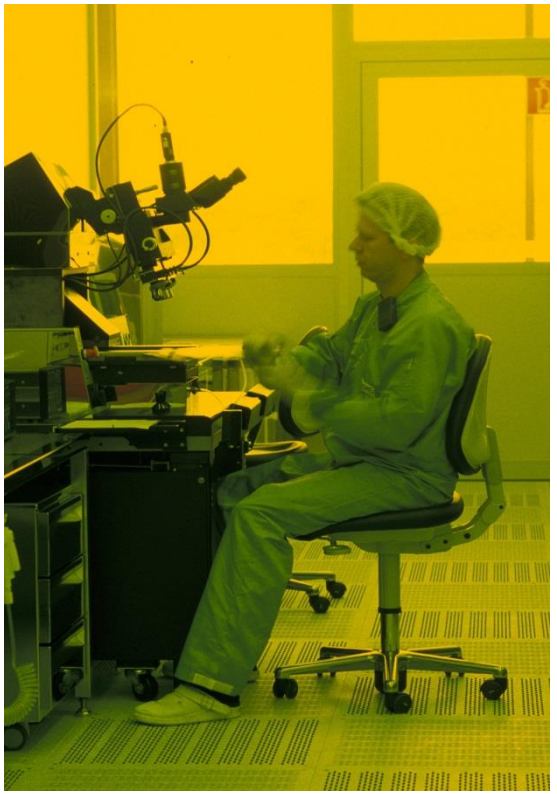


Studies: Non-technical skills

- 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 / ~ 840 students
- **Department of Microsystems Engineering** (IMTEK)
  - 22 professors / ~ 830 students
- Department of Sustainable Systems Engineering (INATECH)
  - 7 professors / ~ 250 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

The curriculum

Structural principles

- MSc. Program = 120 ECTS
- ~ 30 ECTS per semester
- 1 ECTS = 30 hours work load
- Mandatory courses are offered every other semester.
- Exams are offered every semester.
- The exam regulations stipulate *which* courses are to be completed to get the degree, but you can decide *when* you want to take which course and exam.
- It is allowed to study more than 4 semesters.

Modules in the study program

- All programs are organized in modules.
- A module consists of one or several courses and course work.

- **Module Components**
  - Lectures – German: Vorlesung (V)
  - Exercises – German: Übung (Ü)
  - Laboratories – German: Praktikum (Pr) oder Praktische Übung (PrÜ)
  - Seminars – German: Seminar (S)

Course work

- **Non-graded course work (“Studienleistungen”, SL)**
  - Exercises, reports, mid-term exams…
  - Are not part of your final grade, but may be part of a module (for example weekly exercise sheets)
  - May be graded, or only “pass” or “fail”
  - Unlimited number of attempts

- **Graded course work (“Prüfungsleistungen”, PL)**
  - Written or oral exams, reports, presentations,…
  - Are always graded and count into your final grade
  - Limited number of attempts

Mandatory modules I

Module	Type	Exam	ECTS	Sem
Microelectronics	Le+E	Written exam	5	1
Micro-mechanics	Le+E	Written exam	5	1
MST Design Lab I	La	?	3	1
Micro-optics	Le+E	Written exam	5	1
Sensors	Le+La	Written exam	5	1
MST Technologies and Processes	Le+E	Written exam	5	1
Probability and Statistics	Le+E	Written exam	5	1

Le = Lecture, E = Exercise, La = Lab course

Mandatory modules II

Module	Type	Exam	ECTS	Sem
Signal Processing	Le+E	Written exam	5	2
Assembly and Packaging Tech.	Le+E	Written exam	5	2
Biomedical Microsystems	Le+E	Written exam	5	2
Micro-actuators	Le+E	Written exam	5	2
Micro-fluidics	Le+E	Written exam	5	2
Probability and Statistics	Le+E	Written exam	5	2
Master thesis		Thesis and pres.	30	4
Total Mandatory Modules			**58**	

Le = Lecture, E = Exercise, La = Lab course

Elective modules

Choose 2 areas, minimum 9 ECTS max. 23 ECTS in each of them.

Concentration areas	ECTS
Circuits and Systems	9-23
Design and Simulation	9-23
Life Sciences: Biomedical Engineering	9-23
Life Sciences: Lab-on-a-chip	9-23
Materials	9-23
MEMS Processing	9-23
Photonics	9-23
Sensors and Actuators	9-23
Personal Profile	9-23
Total Elective Modules	32

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

Corona Information I

- WS 20/21: All courses (except for lab courses) can be taken online
- Some lecturers will offer on-campus sessions in addition to the online offer
- Online lectures: Either livestream or recorded lectures
- Online exercises: Students will send or upload the exercises they solved. Lecturer will give individual feedback and/or offer Q&A sessions or online forums
- More detailed information will be provided by each lecturer for his/her course by email or via ILIAS
- Written exams can only be taken on-campus

Corona Information II

Faculty of Engineering:

https://www.tf.uni-freiburg.de/en/corona

University:

https://www.studium.uni-freiburg.de/en?set_language=en

Student Services (SWFR):

https://www.swfr.de/en/corona-faqs/

MSE courses, first semester

Mon	Tue	Wed	Thu	Fri
		8-10 **Probability & Stat.** **Lecture** **051-03-026**	8-10 Micro-electronics Exercises 101 00 036	
10-12 **Micromechanics** **Lecture** **online**	**10-12** **Micro-optics** **Lecture** **101 00 036**	**10-12** **Micro-electronics** **Lecture** **101 00 036**	10-12 Probability & Stat. Exercises 051-03-026	10-12 Micromechanics Exercises 101 00 036
	13-14 MST Technologies & Processes Exercises		**13-14** **Sensors Lecture** **Online**	12-14 MST Design Lab) Lab course 082 00 006
	14-16 **Sensors Lecture** **Online**		**14-16** **MST Technologies &** **Processes, lecture**	14-16 Micro-optics Exercises
	16-18 **MST Design Lab I** **Lecture** **051 03 026**		16-18 Sensors Lab 078 00 035	16-18 Sensors Lab 078 00 035
			18-20 Sensors Lab 078 00 035	

Exams: The most important rules

- In addition to registering for a module, you need to **register for every exam** you want to take: https://www.tf.uni-freiburg.de/en/studies-and-teaching/a-to-z-study-faq/de-registration-of-exams
- If **failed**, you can repeat every exam once. Two exams can be repeated twice.
- If you fail an exam, you will automatically be registered for the **retake** in the following semester.
- You can only **withdraw from an exam** if you are ill or if there is an emergency in your family. https://www.tf.uni-freiburg.de/en/studies-and-teaching/a-to-z-study-faq/withdrawl-from-exams
- For more details, make sure to read the exam regulations.

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.

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

- **At the university:**
  - 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. Jürgen Wilde
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  - 203 7291

- **Program coordinator:** Ursula Epe
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  - 203 97940

- **Student advisers:**
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  - Dr. Jochen Kieninger
    - 203 7265
  - 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

Thank you very much for your attention !