Msc. Microsystems Engineering - Introduction to the programme

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The technology

A macrosystem

The Airbus A380

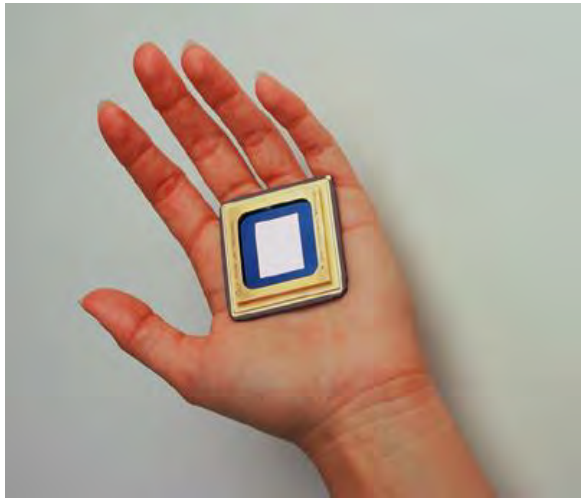
- Approximately 1 Million single parts!
  - One Wing: 32,000 parts
- Costs: $ 275 Millions
  - Average per single part $ 275
- High effort for single part fabrication

Can you imagine such a system with 2 Million parts?

A microsystem

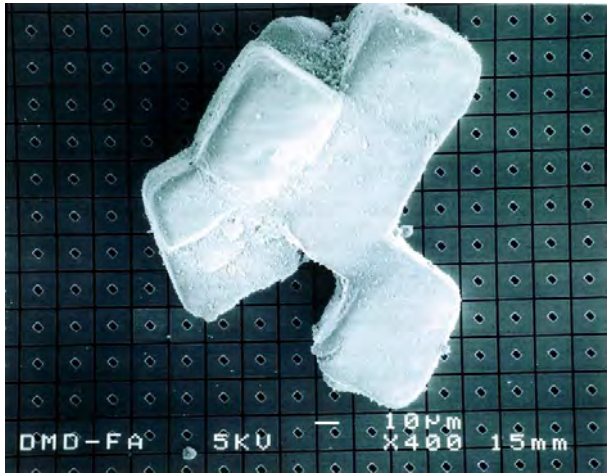
The DMD

- 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

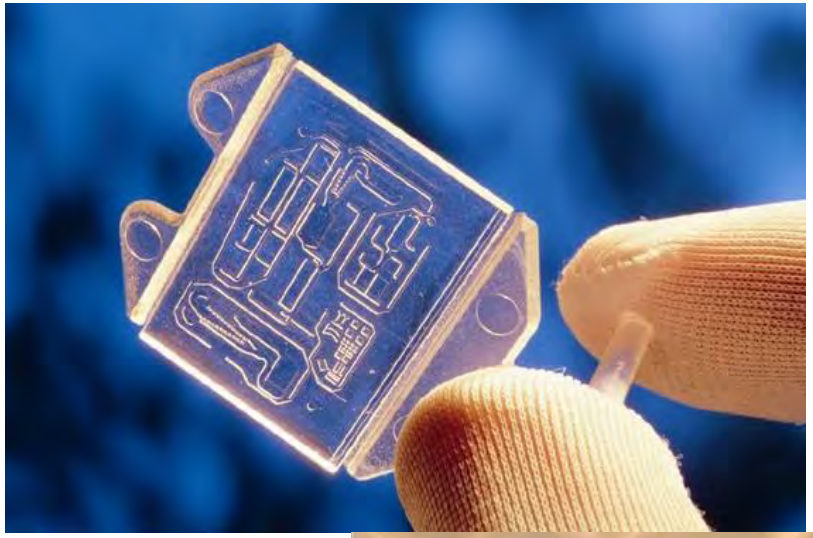


Microsystems

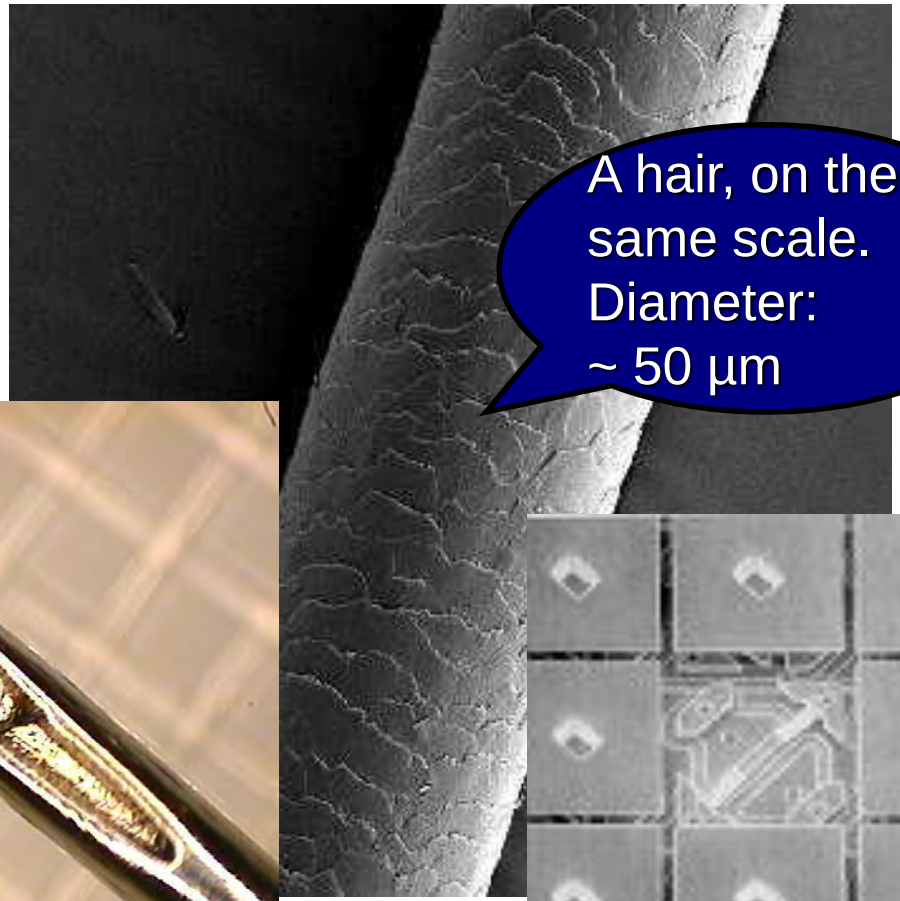
- Many functions
- Small volume



Microsystems are small



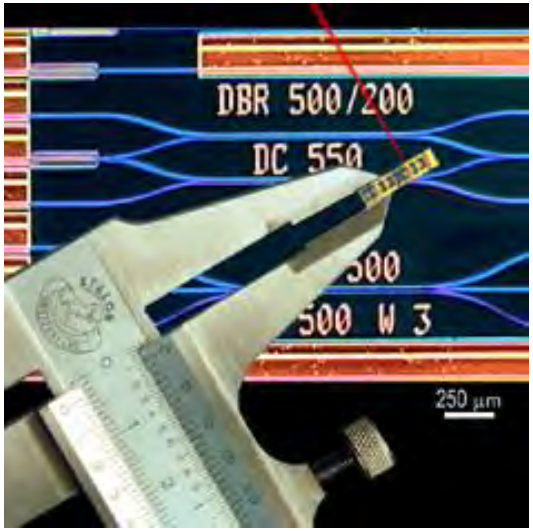
Small

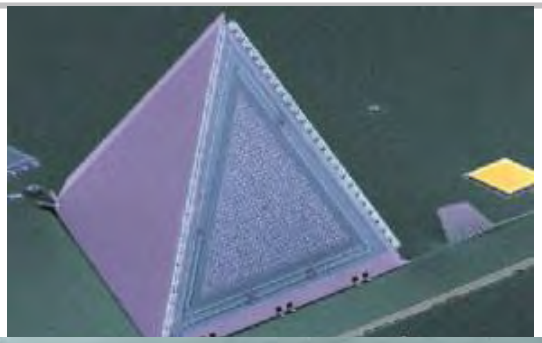


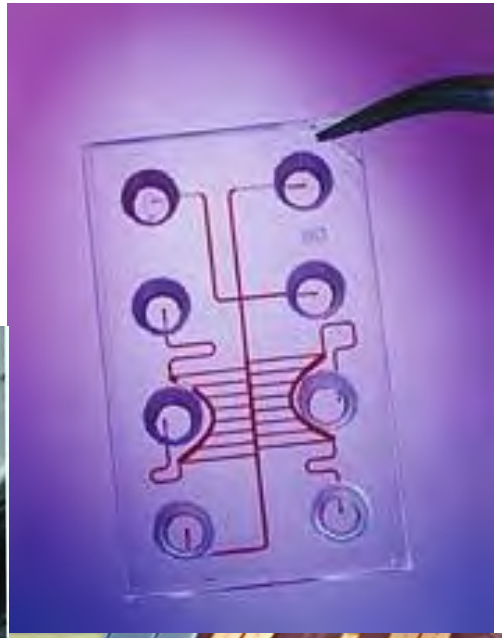
Smaller

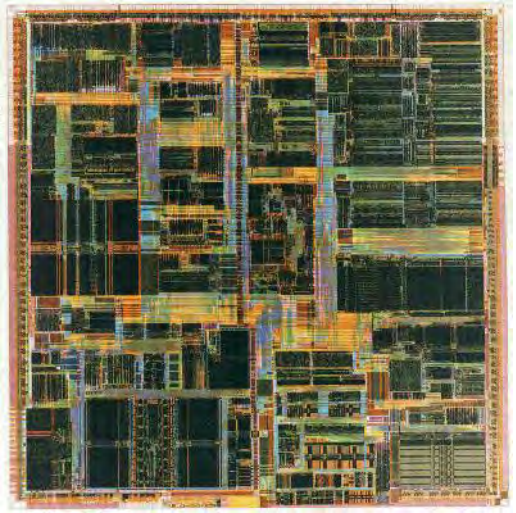
Tiny

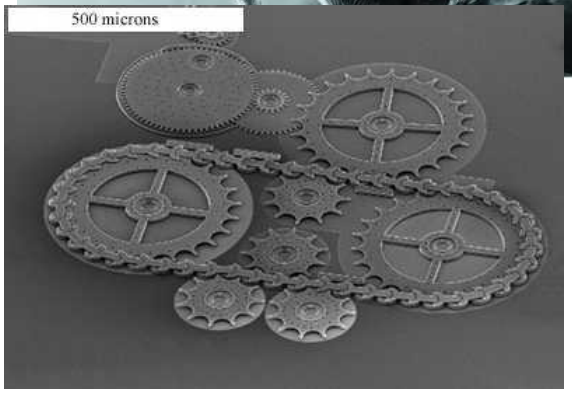
A huge variety in microsystems

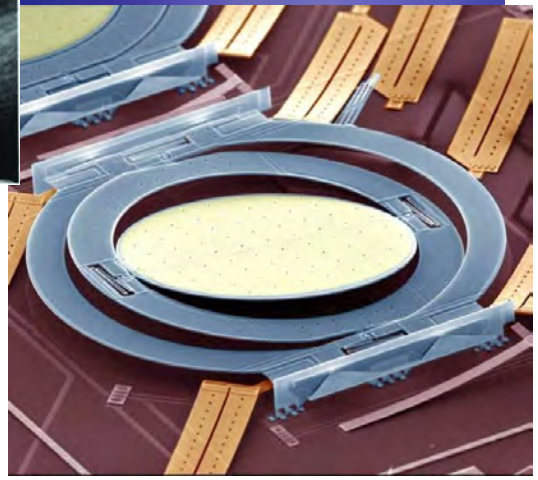






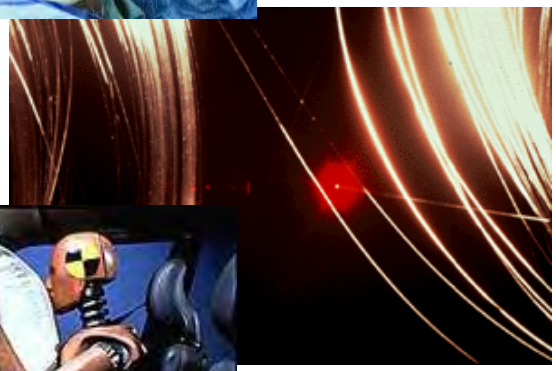






Microsystems are everywhere

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

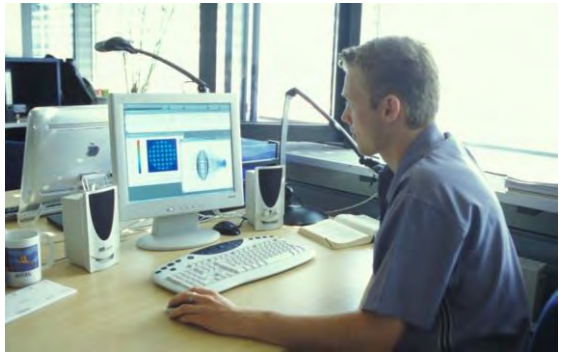


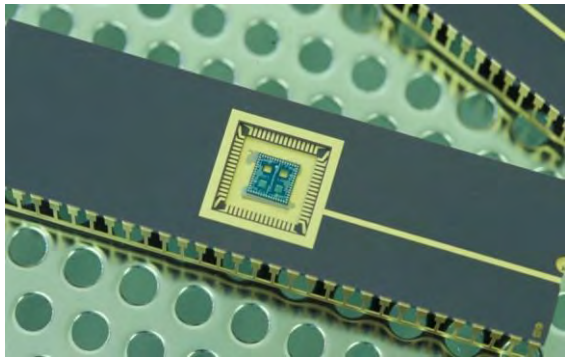
The career

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



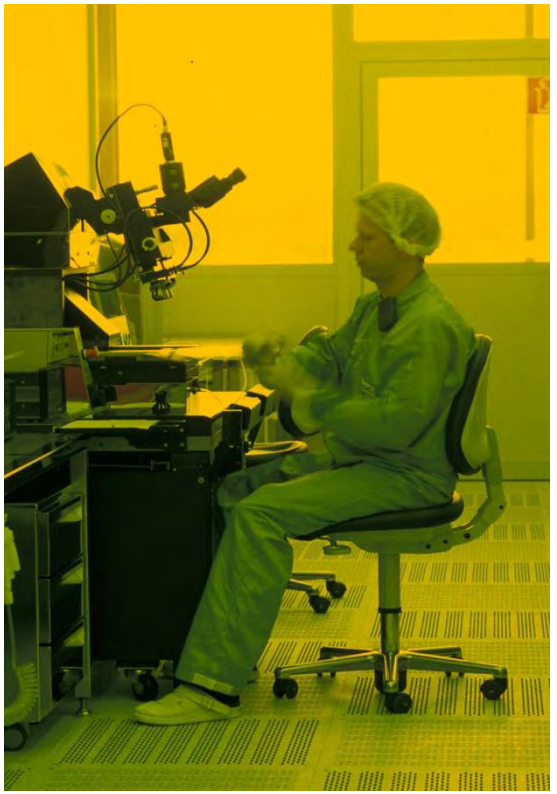


Studies: Non-technical skills

- 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 can 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
- **Electr. Instrumentation & Embedded Sys.**
  Prof. Dr. Stefan Rupitsch
- **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
Deputy: Dr. Matthias Keller
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 the respective 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 judged only as “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, normally only 2

Mandatory modules in MSc MSE

Module	Type	Exam	ECTS	Sem
Microelectronics	Le+E	Written exam	6	1
Micro-mechanics	Le+E	Written exam	6	1
MST Design Laboratory I for Microsystems Engineering	La	Studien-leistung	6	1
MST Technologies and Processes	Le+E	Studien-leistung Written exam	6	1
Signal Processing	Le+La	Written exam	6	2
Master‘s Module (6 months)		Thesis + Presentation	27 + 3	4

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

Compulsory Electives: Advanced Microsystems
➔ Choose 5 of 8

Module	Type	Exam	ECTS	Sem.
Assembly and Packaging Technology	Le+E	Written exam	6	1, 2 or 3
Micro-optics	Le+E	Written exam	6	1 or 3
Modelling and System Identification	Le+E	Written exam	6	1 or 3
Probability and Statistics	Le+E	Written exam	6	1 or 3
Sensors	Le+E	Written exam	6	1 or 3
Biomedical Microsystems	Le+E	Written exam	6	2
Micro-actuators	Le+E	Written Exam	6	2
Micro-fluidics	Le+E	Written Exam	6	2
Total to be selected			**30**	

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

Concentration Areas + Customized Courses

Concentration areas (21-30 ECTS)	ECTS
Circuits and Systems	Students have to choose one concentration area
Materials and Fabrication	
Biomedical Engineering	
Photonics	
Total	21-30

Customized Course Selection	ECTS
Courses from other faculties at the University of Freiburg, also courses on German language, scientific writing, project management	Students can chose
Courses from the MSc MSE program	
Total	9

Elective modules in concentrations

Circuits and Systems

- Angewandte Sensorschaltungstechnik
- Bayesian Methods for Sensing
- CMOS MEMS
- Wireless Sensor Systems
- Energy harvesting
- Analog CMOS Circuit Design
- Mixed-Signal CMOS Circuit Design
- Flight Control Laboratory
- Advanced Assembly and Packaging Technology
- Advanced Microcontroller Lab
- Power Electronics for E-Mobility
- Micro Acoustical Transducers
- Microcontroller Techniques - Praktikum
- Model Predictive Control and Reinforcement Learning
- MST Design Lab II for Microsystems Engineering
  Numerical Optimal Control in Engineering - Project
- Numerical Optimization
- Numerical Optimization Project
- Race Car Control Laboratory
- RF- and Microwave Devices and Circuits
- RF- and Microwave Circuits and Systems
- RF- and Microwave Systems- Design Course
- Sensors and actuators circuit technology
- State Space Control Systems
- Thermoelektrik und thermische Messtechnik
- Wind Energy Systems
- Reliability Engineering

Materials and Fabrication

- Computational physics: material science
- Disposable sensors
- Electrochemical energy applications: fuel cells and electrolysis
- Electrochemical Methods for Engineers
- Energy storage and conversion using fuel cells
- Fortgeschrittene Siliziumtechnologie / Advanced Silicon Technology
- Functional Safety, Security and Sustainability: Active Resilience
- Hardware Design with the Finite-Element-Method
- Ceramic Materials for microsystems
- Contact, Adhesion, Friction
- Continuum mechanics I with exercises
- Continuum mechanics II with exercises
- Physics of Failure
- Lithography
- Materials for Electronic Systems
- Mechanical Properties and Degradation Mechanisms
- Methods of Material Analysis Microstructured Polymer Components
- Nanomaterials
- Nanotechnology
- Nano - Laboratory
- Surface Analysis
- Surface Analysis Laboratory
- Optimierung
- Advanced engineering
- Polymer Processing and Microsystems Engineering
- Quantum Mechanics for Engineers
- Clean Room Laboratory for Engineers
- Quantification of Resilience
- Solar Energy
- Techniken zur Oberflächenmodifizierung / Surface coating Techniques
- Compound semiconductor devices
- From Microsystems to the Nanoworld
- Dynamics of Materials: Material Characterization

Elective modules in concentrations

Biomedical Engineering

- Analyse von Life Science Hochdurchsatzdaten mit Galaxy
- Selected Problems in Biosignal Processing
- Biofunctional Materials - for medical microsystems and healthcare
- Biomedical Instrumentation I
- Biomedical Instrumentation II
- Biomedical Instrumentation - Laboratory
- BioMEMS
- Bionic Sensors
- Biophysics of cardiac function and signals
- Biophysik - Grundlagen und Konzepte
- Biotechnologie für Ingenieure I: Einführung, Molekular- Biotechnology for Engineers I: Introduction, Molecular- and Microbiology
- Biotechnology for Engineers II
- Ethical Aspects of Neurotechnology
- Fundamentals of electrical stimulation
- Introduction to data driven life sciences
- Introduction to physiological control systems
- Machine Learning
- Microfluidics II: Miniaturize, automate and parallelize biochemical analysis: From idea to product launch
- Microsystems technology in Medicine
- Nanobiotechnology
- Neurophysiology - Laboratory
- Neuroprosthetics
- Neuroscience for Engineers
- Signal processing and analysis in brain signals
- Silicon-based Neural Technology
- Implant Manufacturing Technologies
- Implant Manufacturing Technologies - Laboratory
- Biointerfaces I - Basics for Bioanalytical Systems

Photonics

- Advanced Topics in Micro-Optics
- Lasers
- Basic Optics Lab
- Basic and Advanced Optics Lab
- Optical Materials
- Optical Properties of Micro and Nano Structures
- Optical Trapping and Particle Tracking
- Optical MEMS
- Optical Measurement Techniques
- Optical Micro-Sensors
- Optoelectronics
- Photonic Microscopy
- Photovoltaic Energy Conversion for engineers
- Photovoltaic Energy Conversion for engineers II
- Spektroskopische Methoden
- Wave Optics

Corona Information I & 3G procedure

- WS 21/22: 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 live-stream 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 SR 01-009/13 building 101	8-10 Probability & Stat. Excercises SR 01-009/13 building 101	8-10 Micro-electronics Exercises HS 00 026 µ -lecture hall (building 101)	
10-12 Micromechanics Lecture HS 00 026 µ -lecture hall (building 101)	10-12 Micro-optics Lecture SR 00-010/14 building 101	10-12 Micro-electronics Lecture HS 00 026 µ -lecture hall (building 101)	12-13 Sensors Lecture SR 01-009/13 Building 101	10-12 Micromechanics Exercises 101 00 010/14
	13-14 MST Technologies & Processes Exercises SR 01-009/13 building 101		12-14 Micro-optics Exercises SR 01-016/18 Building 101	12-14 MST Design Lab I Lab course online
	14-16 Sensors Lecture SR 01-009/13 Building 101		14-16 MST Technologies & Processes, lecture SR 00-010/14 building 101	14-16 Micro-optics Exercises SR 00-006 Building 051
	16-18 MST Design Lab I Lecture HS 00-006, building 082		16-18 Sensors Lab 00 035 Building 078	16-18 Sensors Lab 00 035 Building 078
			18-20 Sensors Lab 00 035 Building 078	

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
  - juergen.wilde@imtek.de
    0761-203 7291

- **Program coordination:**

Svenja Andresen

  - studiengangkoordination.mst@imtek.uni-freiburg.de
    0761-203 97940

- **Student advisors:**
  - studienberatung@imtek.de

- Dr. Jochen Kieninger
  0761-203 7265
- Dr. Oswald Prucker
  0761-203 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 !