universität freiburg

M.Sc. Microsystems Engineering-Introduction

Prof. Dr.-Ing. habil. Bastian E. Rapp

Freiburg, 10/10/2023

IMTEK

About me

Prof. Dr.-Ing. habil. Bastian E. Rapp

Full Professor,
Laboratory of ProcessTechnology
Department of Microsystem Technology (IMTEK)
University of Freiburg

- 2005, mechanical engineering
  University of Karlsruhe
- 2008, PhD in Microfluidics and Biosensors
  University of Karlsruhe
- 2017, Habilitation on fluid mechanics and microfluidics
  Karlsruhe Institute of Technology (KIT)
- 2018, Full Professor Process Technology
  IMTEK, University of Freiburg
- 2018, Founding CEO and current CTO of Glassomer GmbH
- several industry/academic awards (selection):
  GMM, *Edison Award*, *Südwestmetallförderpreis,* 2 of my former PhD students won the *Deutsche Studienpreis*
- since WS 2023/2024: Dean of Studies of IMTEK

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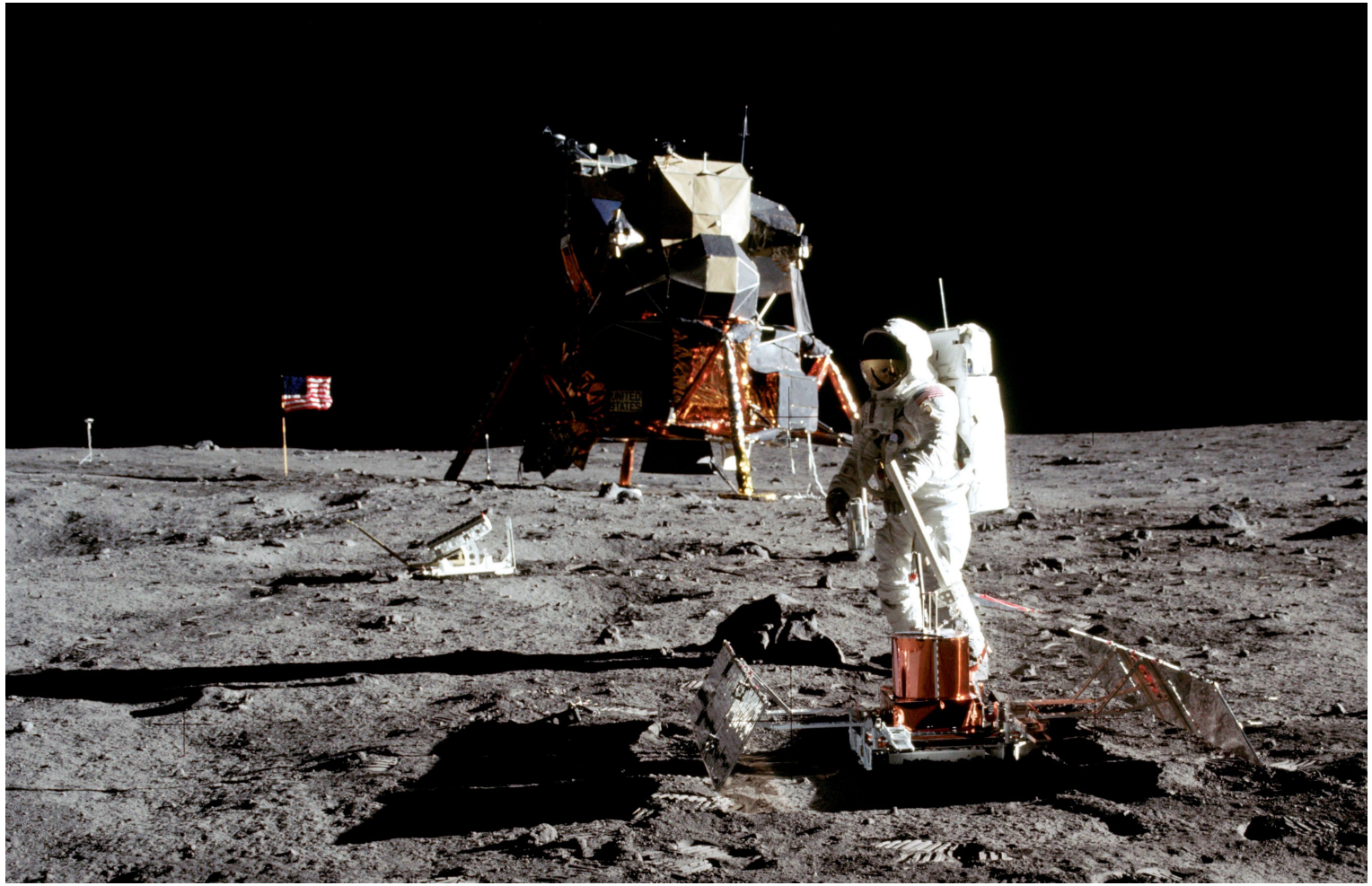
The Technology

One of the greatest achievements of mankind

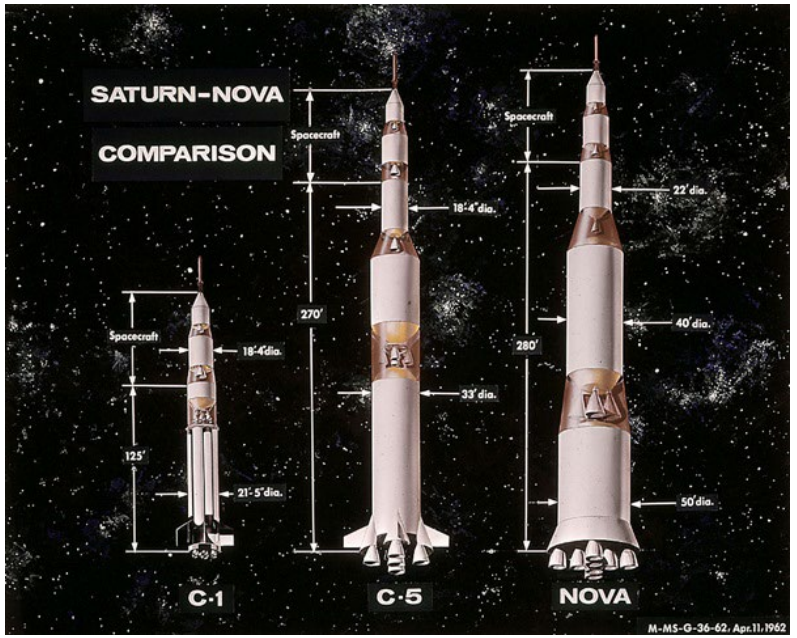


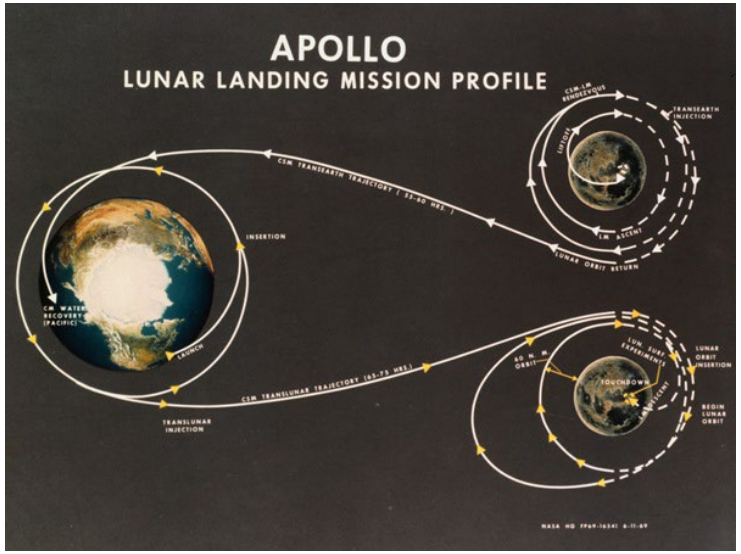
- the lunar landing of *Apollo 11* on July 20th, 1969
- you all know the story but how much do you know about the technology behind *Apollo*?

nasa.gov, media library, 17/10/2022

How do you actually get to the moon? In 1969?

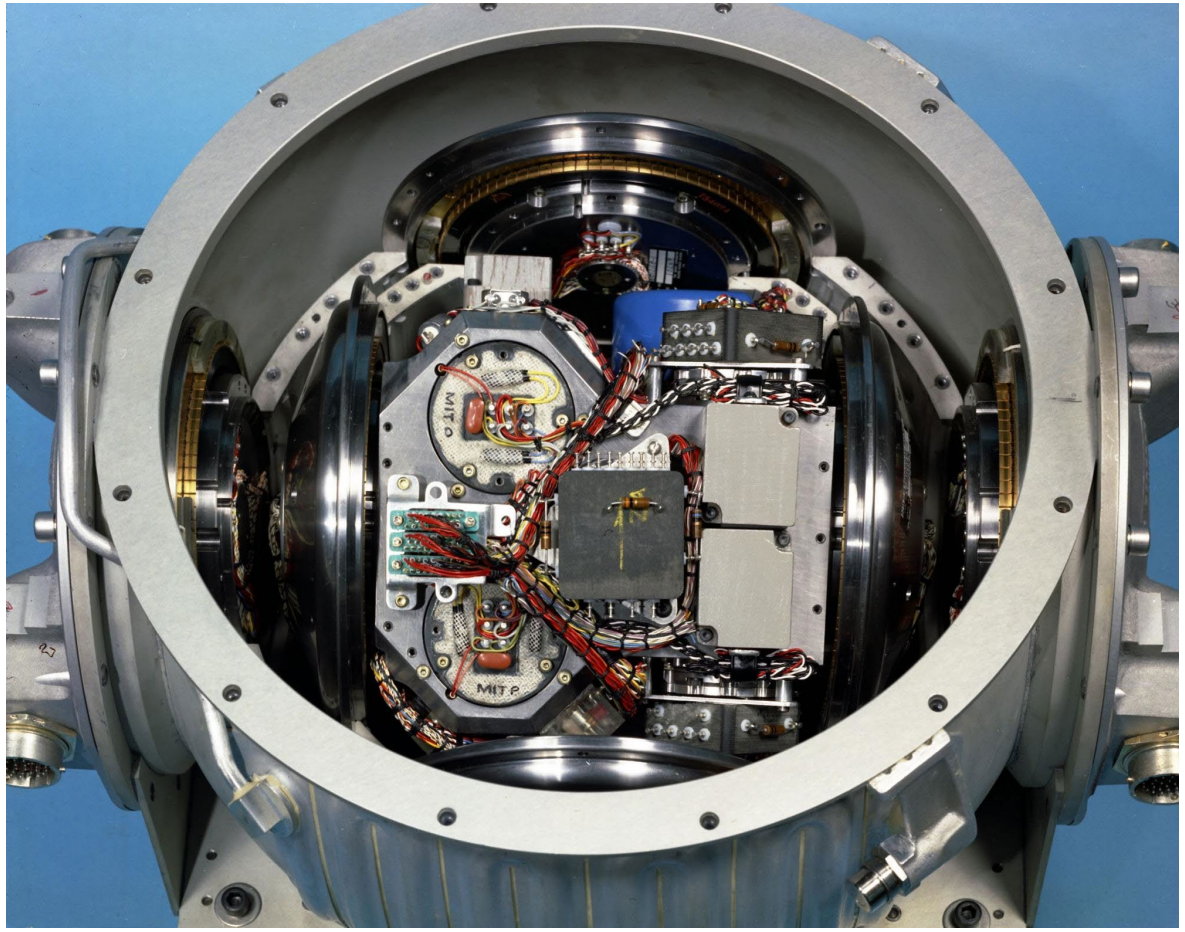
- in order to reduce the rocket size NASA chose the so-called *Lunar orbit rendezvous* configuration instead of building a *Nova* rocket
- this meant that the Apollo 11 not only had to get to the moon (a 3-day = 300,000 miles journey) but also dis-engage (and later re-engage) the landing module



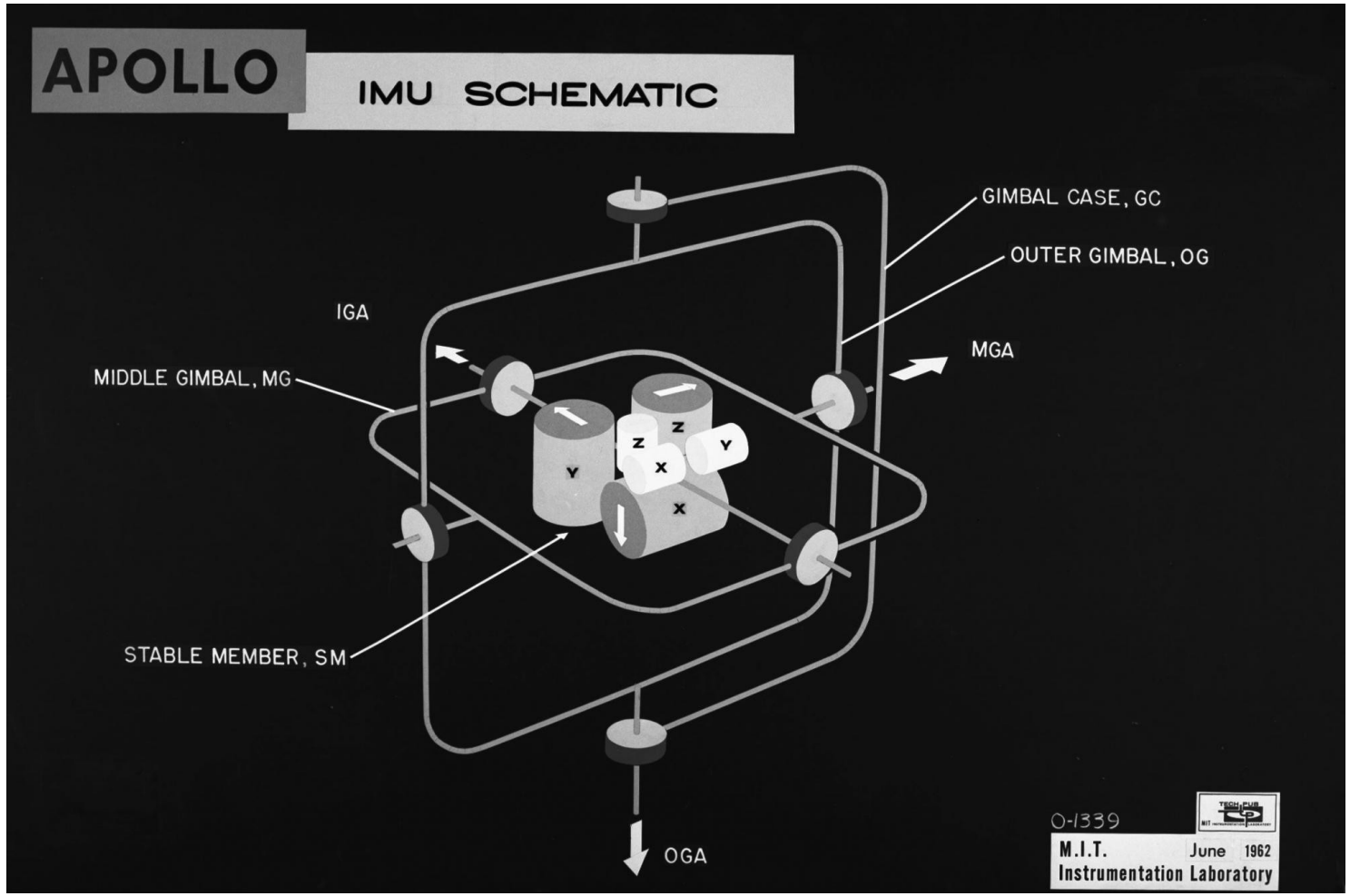


- how to you navigate that precisely, so far away from earth in 1969?
- satellites → out of range
- GPS → not invented yet
- the stars → way to imprecise

This is how you do this: But what exactly is this?

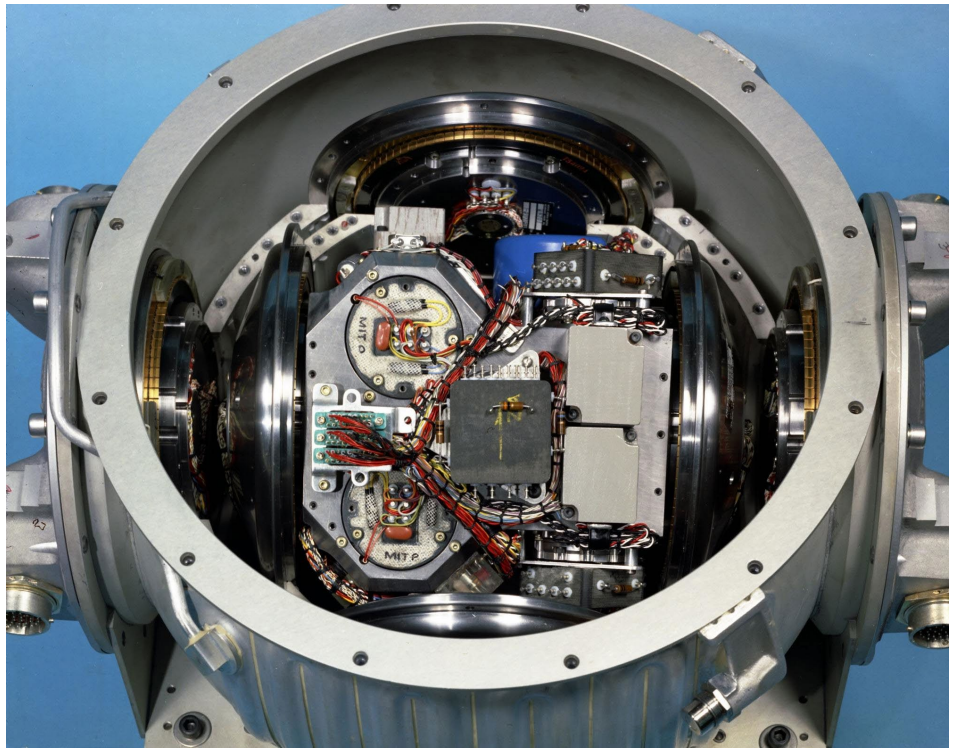


The Inertial Measurement Unit (IMU) via a sketch by Draper himself



- by precisely measuring the orientation (with a gyroscope) and the acceleration (using an accelerometer) you can precisely calculate your position
- this is because
$$\vec{a} = \frac{d\vec{v}}{t} = \frac{d^2\vec{s}}{dt^2}$$
- if you integrate the acceleration you will always now your position
- you need to integration constants:
  - $\vec{s}_0$ = location of Cape Canaveral
  - $\vec{v}_0 = 0$

How do we navigate today? IMUs to the rescue again! However ….



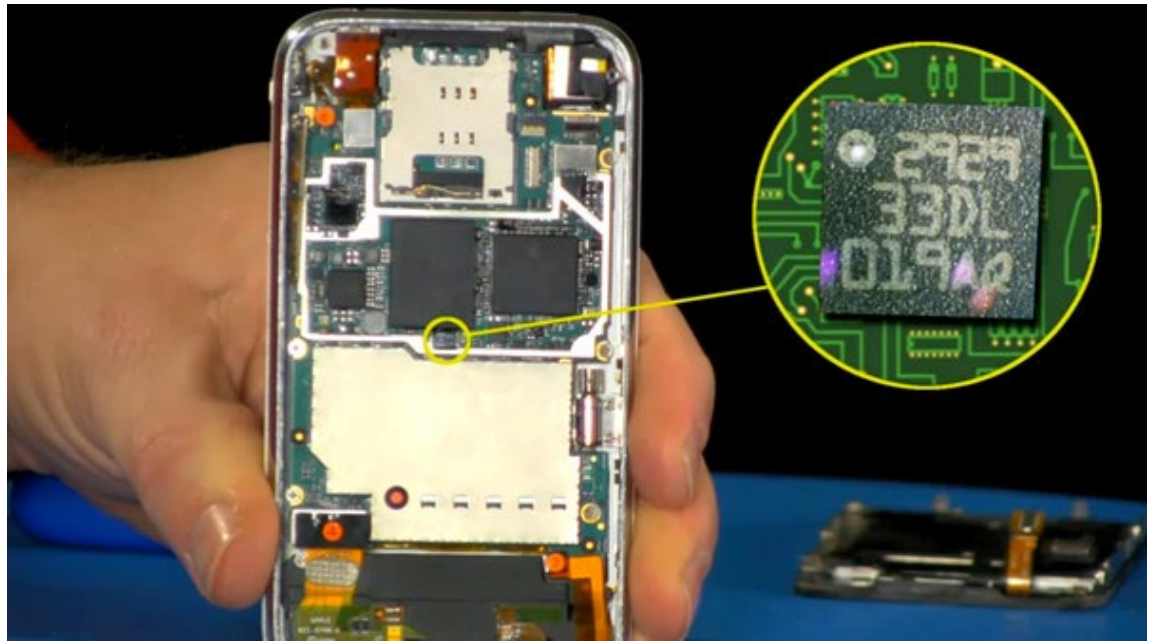
Ultra-low-power
6-axis industrial-grade IMU

- 50 years later, the fridge-sized instruments is about the size of your pinky's nail
- accelerometers can be shrunk to the size of needle pin

wehackthemoon.com, 17/10/2022; st.com, 17/10/2022

Need proof? Phones out!

- this is an IMU which outperforms Apollo's on-board IMU by two orders of magnitude!
- and this image is from 2012!
- costs? 0.08 Euro ☺



So how did we get from a fridge-sized devices to something which we all carry in our pockets?

Ladies and Gentlemen: Microsystems Technology

Next time somebody asks you what exactly you study, you could tell them:
We put space science in your pocket – and help return mankind to the moon (and beyond) – among many, many, many other things.

engadget.com, 17/10/2022

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

AIRBUS

Can you imagine such a system with 2 Million parts?

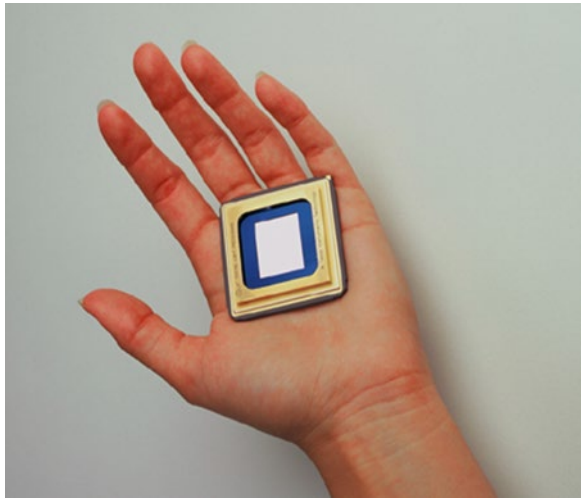
A microsystem

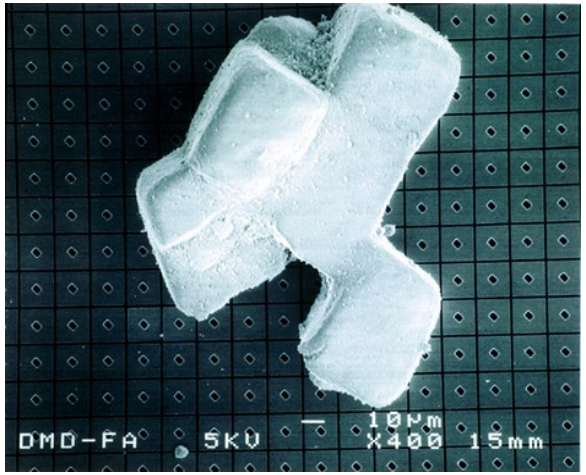
The DMD

- 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

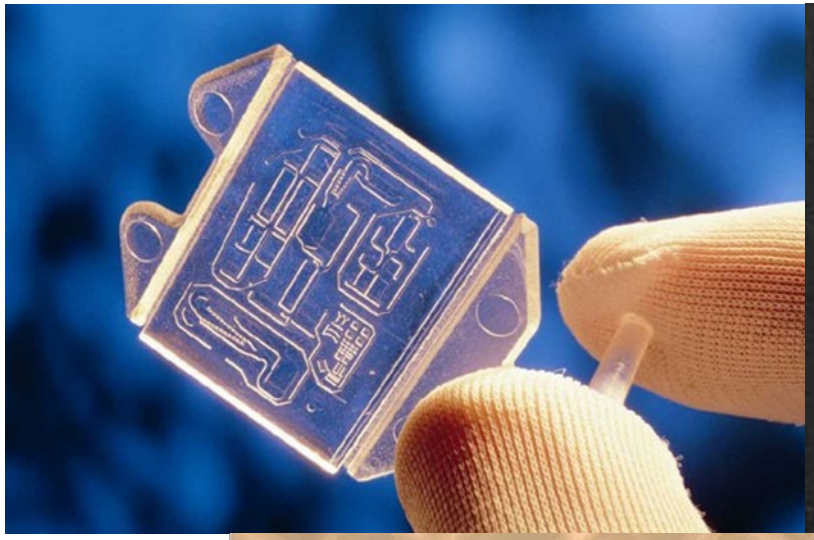
Microsystems

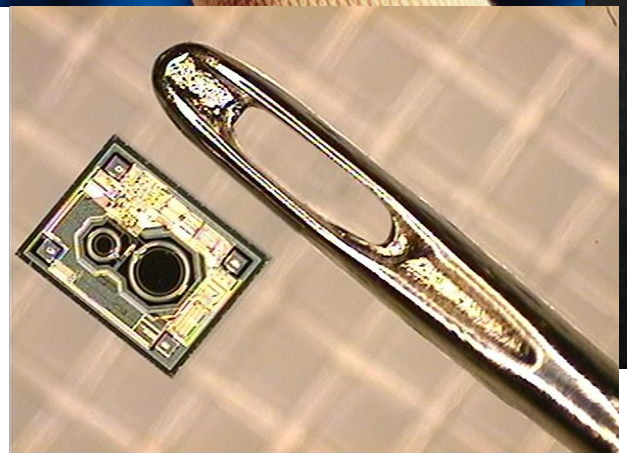
- Many functions
- Small volume



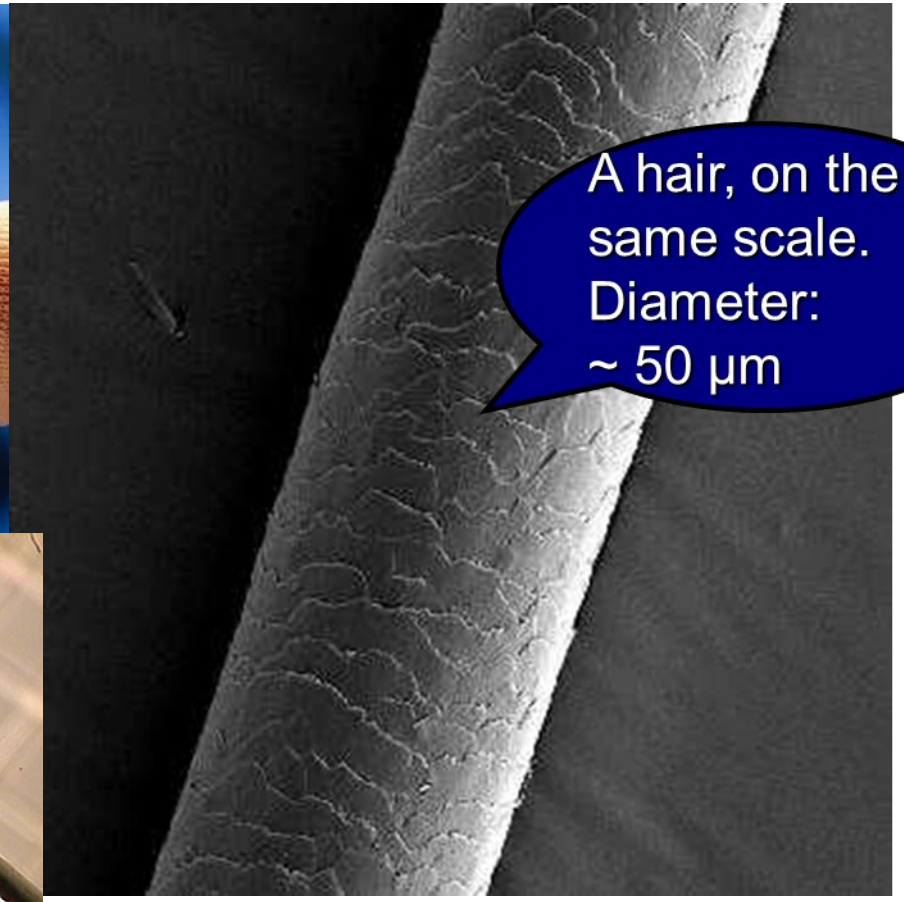


Microsystems are small



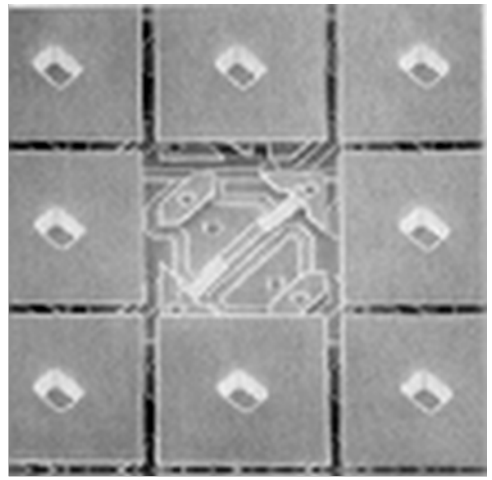


Smaller

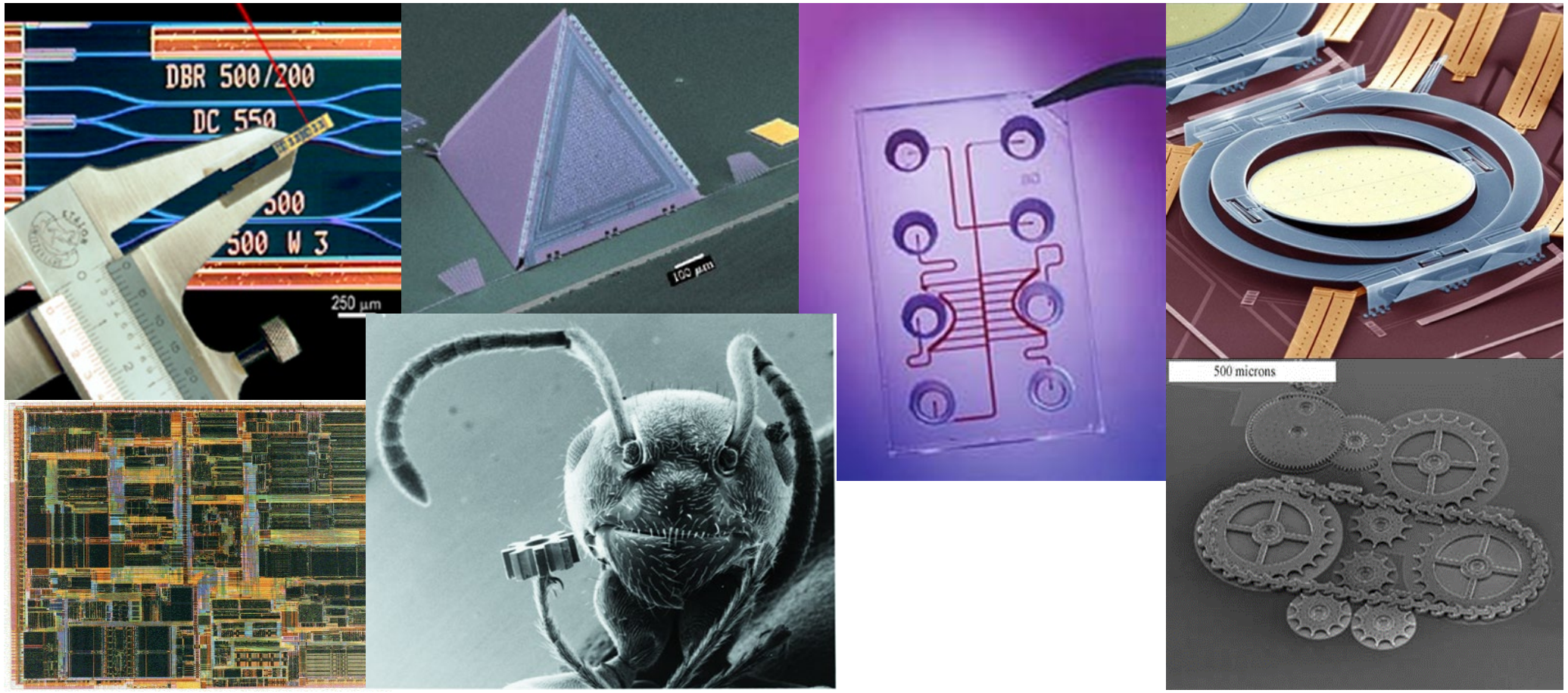


Small

Tiny



A huge variety in microsystems



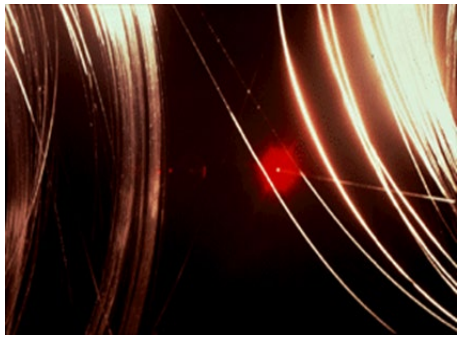
Microsystems are everywhere

Medicine

- Minimally-invasive surgery
- Diagnostics

Communications

- Fiber optics
- Mobile phones

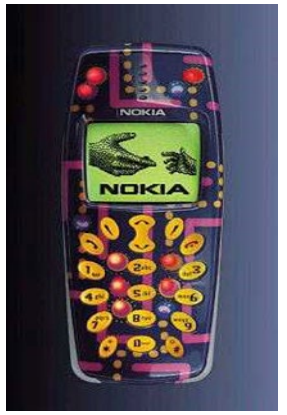


Consumer

- Autonomous networks
- Sensors

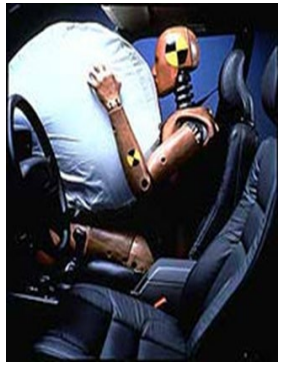
Industry

- 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

The challenge starts now

Design & development

– Fabrication

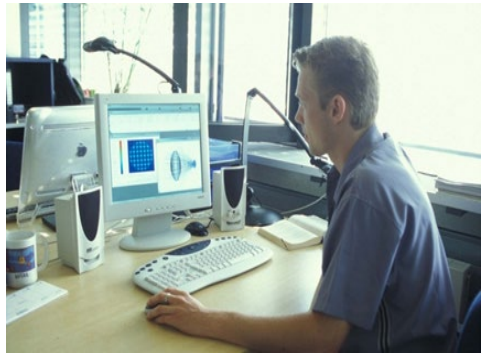
– Characterization & optimization

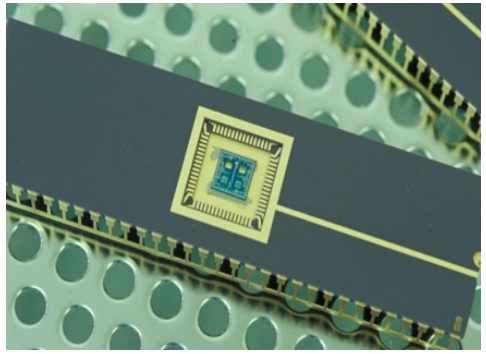
– Packaging

– System testing & qualification

– Transfer to production

– Marketing





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:

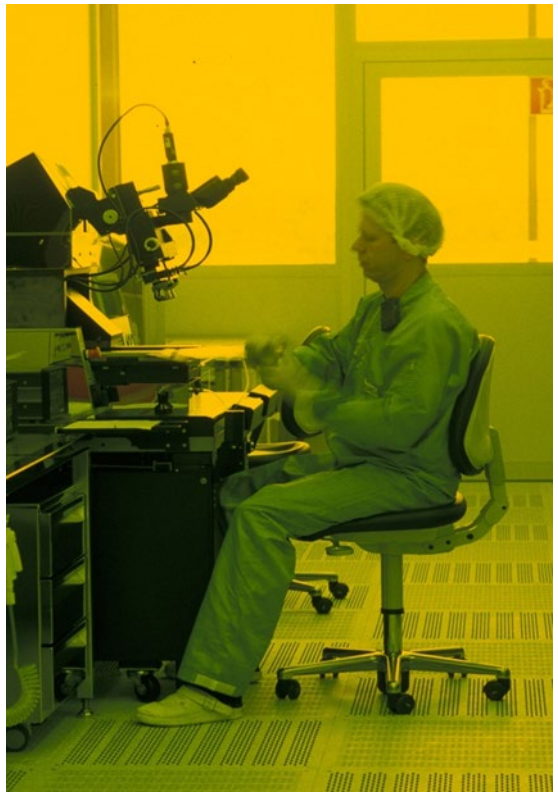
- Entrepreneurs, technicians, engineers, group leaders, managers, CEOs, astronauts,…

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

Students | head count

Students | Graduates | Research | Staff

Faculty
Faculty of Engineeri..

Current numbers | WS 2023/24 (fall semester)

WS 2023/24
2,571
Students enrolled
▲ 3.75% to WS 2022/23


female

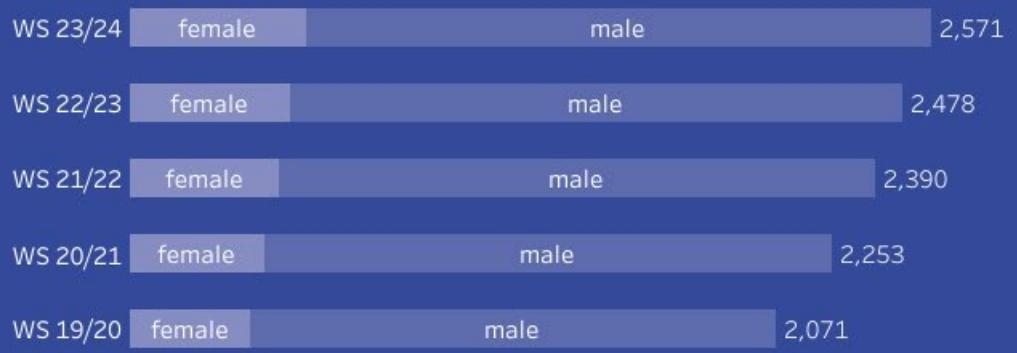
– **22%** | 562
2,007 | **78%** –
2 Stud. unknown/diverse


male

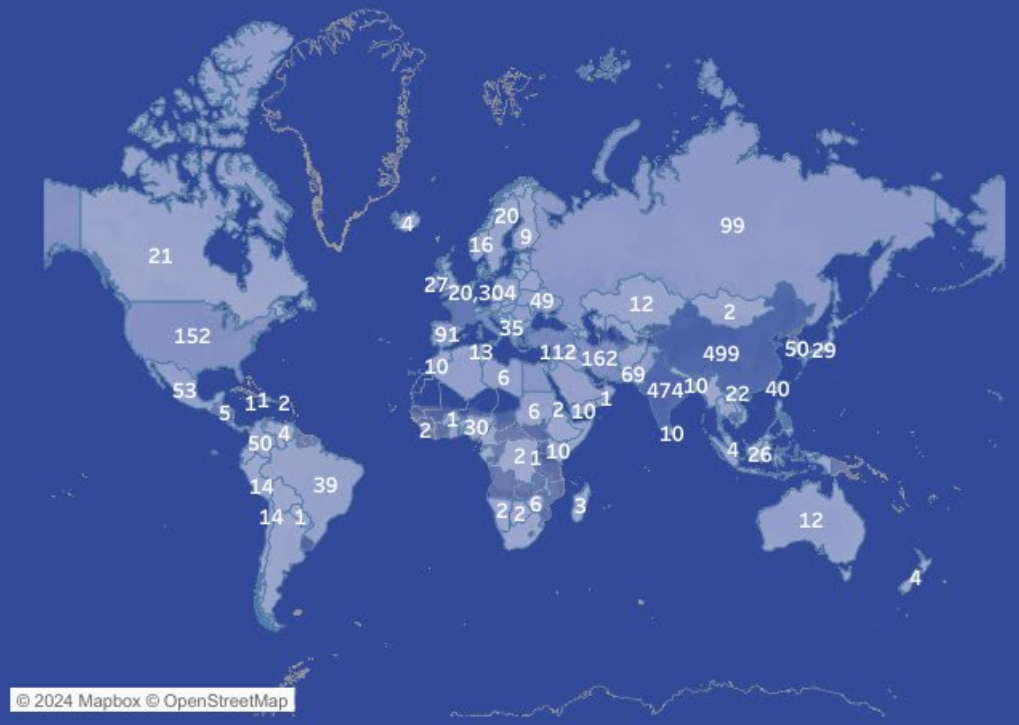
36%
International Students

WS 2023/24
573
First-year students
▲ 6.90% to WS 2022/23

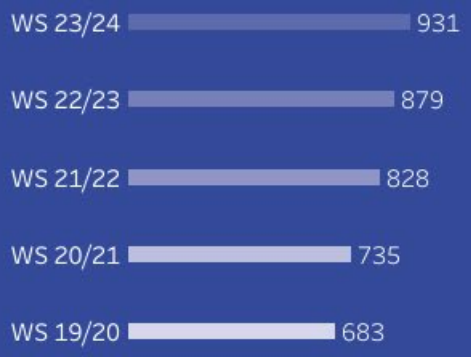
Development of student numbers



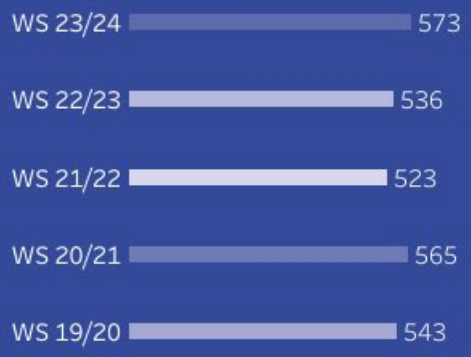
Students by citizenship



International students



First-year students



Data: **25 September 2024** | D1.2 Controlling and Information Management

universität freiburg

Faculty of Engineering

- Faculty in operation since 1995
- Department of Computer Science (IIF)
- 20 professors / ca. 100 scientific staff/~ 950 students
- Department of Microsystems Engineering (IMTEK)
- 22 professors /ca. 300 scientific staff/ ~ 880 students
- Department of Sustainable Systems Engineering (INATECH)
- 11 professors / ~ 380 students

IMTEK-Professors

IMTEK Laboratories

MEMS Applications
Prof. Dr. Roland Zengerle
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
Hahn-Schickard-Institute of Microanalysis Systems
Prof. Dr. Felix von Stetten
Materials Processing
Prof. Dr. Thomas Hanemann
Micro- and Material Mechanics
Prof. Dr. Christoph Eberl

Microactuators
Prof. Dr. Ulrike Wallrabe
Microelectronics
Prof. Dr. Matthias Kuhl
Micro-optics
Prof. Dr. Hans Zappe
Microsystems for Biomedical Imaging
Jun.Prof. Dr. Caglar Ataman
Microsystems Materials
Prof. Dr. Oliver Paul
Optical Systems
Prof. Dr. Carsten Buse
Process Technology
Prof. Dr. Bastian E. Rapp
Sensors
Jun.Prof. Dr. Alwin Daus
Simulation
Prof. Dr. Lars Pastewka
Smart Systems Integration
Prof. Dr. Alfons Dehé
Soft Machines
Jun.Prof. Dr. Edoardo Milana
Systems Control and Optimization
Prof. Dr. Moritz Diehl

The Curriculum

Structural principles

- M.Sc. Programme = 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

Mandatory modules

Module	Type	Exam	ECTS	Semester
Micro-electronics	Le-E	Written exam	6	1
Micro-mechanics	Le+E	Written exam	6	1
MST Design Laboratory I for Microsystems Engineering	La	Pass/Fail assessment (Studienleistung)	6	1
MST Technologies and Processes	L+E	Pass/Fail assessment (Studienleistung) Written exam	6	1
Signal Processing	L+La	Written exam	6	2
Master‘s module (6 months)		Thesis and presentation	27+3	4

Compulsory elective modules

Module	Type	Exam	ECTS	Semester
Assembly and Packaging Technology	Le+E	Writen exam	6	1, 2 or 3
Mirco-optics	Le+E	Written exam	6	1 or 3
Modelling and Sytstem Identification	Le-E	Written exam	6	1 or 3
Probability and Statistics	Le-E	Written exam	6	1 or 3
Sensors	Le+La	Pass/fail assessment Written exam	6	1 or 3
Biomedical Microsystems	Le+E	Written exam	6	2
Micro-actuators	Le+E	Pass/fail assessment Written exam	6	2
Micro-fuidics	Le+E	Written exam	6	2
Total to be selected			**30**	

Concentration Areas and Customized Course Selection

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 the MSE concentrations, other faculties at the University of Freiburg, also courses on German language, scientific writing, project management	Students can choose either 30 concentration or 21 concentration+9 CCS
Total	**9**

More details on course structure, exam regulations etc.

- … will be provided directly after I‘m done here.
- Will afterwards be available through video tutorials at:
  https://www.tf.uni-freiburg.de/en/studies-and-teaching/a-to-z-study-faq/freshers-info
- Topics handled there:
  - Understanding the regulations for the curriculum and designing your personal study plan
  - Administrative matters
  - Quick introduction to rules for examinations
  - Finding information and help
  - Using HISinOne to book your courses and exams

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 Programme Coordinator

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 programme
- Use job portals and company websites to monitor the market
- Visit career workshops to gather tips how to apply
- Go to recruiting fairs

Ph.D. 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

Problems with your studies? Or other issues?

- If you have any questions or problems:

  Act immediately and do not procrastinate!

- Contacts & info sources:
  - Official information sources by university, faculty and study programme
  - Academic advising
  - Lecturers / assistants / mentors
  - Fachschaft (faculty's student committee)
  - Information centers like the Student Service Center, Office of Student Services etc.
  - Fellow students

Gegen sexuelle Belästigung, Gewalt und Stalking
Against Sexual Harassment, Violence, and Stalking

Foto:The KonG – stock.adobe.com

Beratung? Counselling?

+49 761 203-4222

+49 152 22928696

www.gleichstellungsbuero.uni-freiburg.de

universität freiburg

Some thoughts to share…

- **A Master‘s programme in Germany: <u>A University is NOT a school!</u>**
  - 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 MSE and their applications to broaden your knowledge and increase the opportunities 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.

Contact persons I

- **Dean of studies**
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- **Programme coordination**
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    - 203 97940

- **Study advisors**
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203 97530

Student Council

- Representation of students' interests in various committees
- Shaping campus life
- Open ear for students with questions and problems
- Exam database
- More info under **https://fachschaft.tf.uni-freiburg.de/**

Thank you very much for your attention!