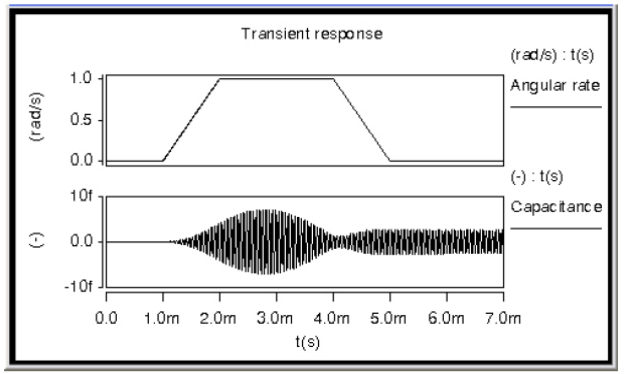
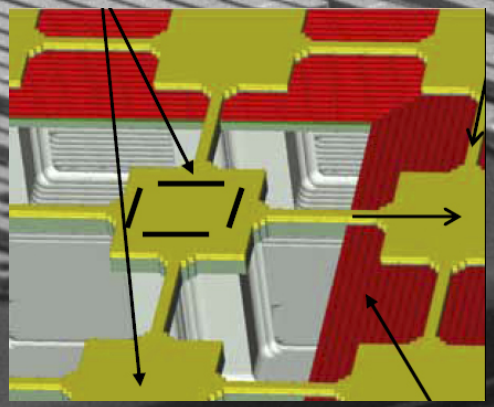
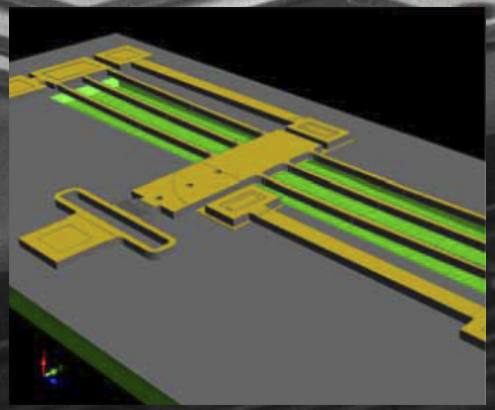
EK2360 Hands-on Micro-Electro-mechanical Systems Engineering

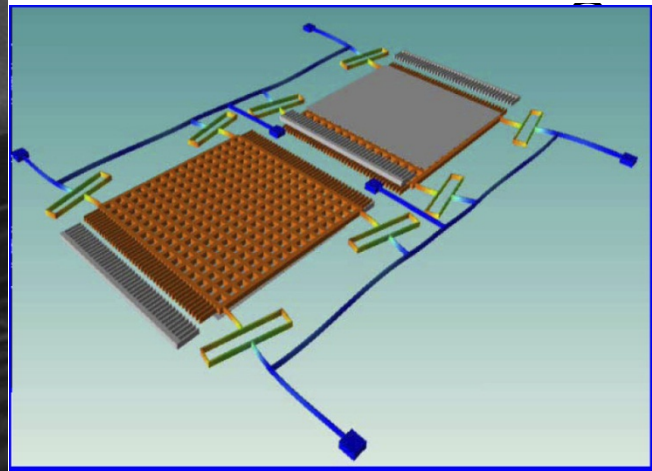
EK3360 Advanced Hands-on MEMS Engineering

2015



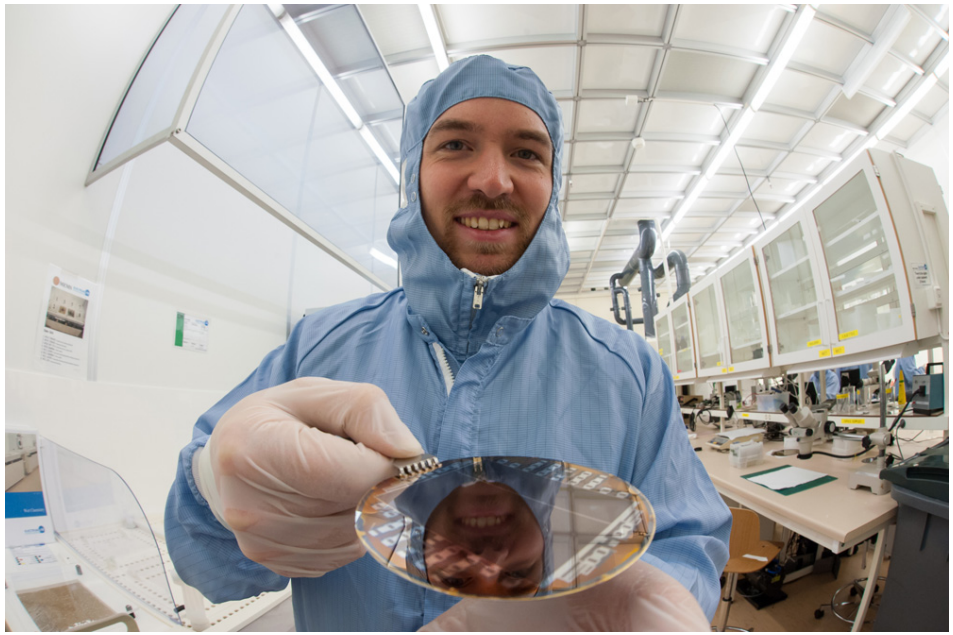


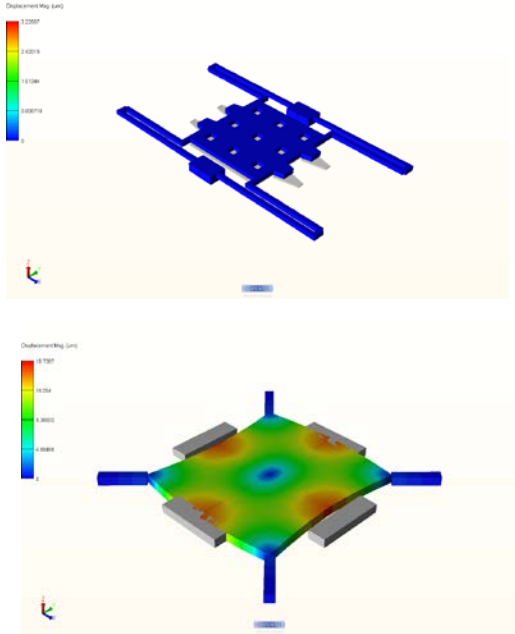




About the Course ...

- “hands-on” project-work experience in microsystem technology (MEMS)
- students design, simulate, fabricate and evaluate their own micro-electromechanical device concepts
- 7.5 ECTS credits (=200h), HT-P2, November-January





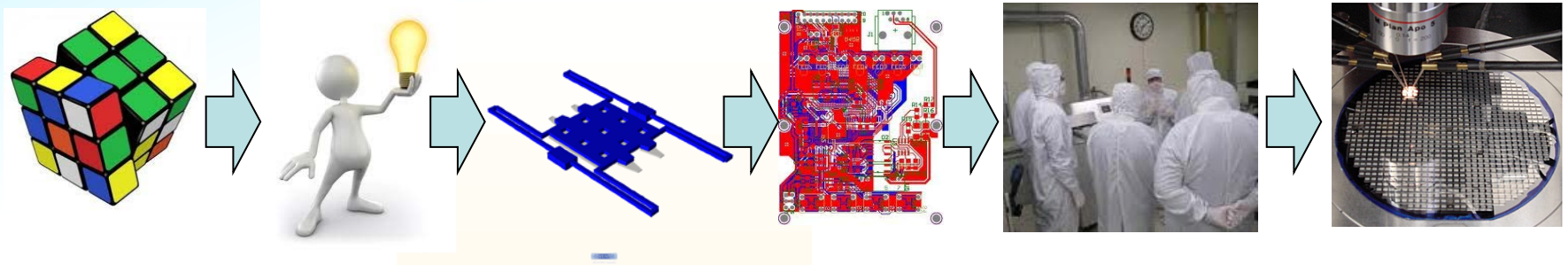
Joachim Oberhammer

Example: Last year's results

Feedback of students in previous years

- 2014:
  - 11 students took the course (7 MSc and 4 PhD students)
  - 57% of the MSc students considered the course among the top 10% KTH courses
  - 100% of the MSc students considered the course among the top 25% KTH courses
  - 100% of the MSc students would take this course again
- 2013:
  - 6 students took the course (5 MSc and 1 PhD students)
  - 33% of the MSc students considered the course among the top 10% KTH courses
  - 100% of the MSc students considered the course among the top 25% KTH courses
  - 100% of the MSc students would take this course again
- 2012:
  - 10 students took the course (6 MSc and 4 PhD students)
  - 50% of the MSc students considered the course among the top 10% KTH courses
  - 83% of the MSc students considered the course among the top 25% KTH courses
  - 100% of the MSc students would take this course again
- 2011:
  - 14 students took the course (10 MSc and 4 PhD students)
  - 30% of the MSc students considered the course among the top 10% KTH courses
  - 70% of the MSc students considered the course among the top 25% KTH courses
  - 80% of the MSc students would take this course again.
- Comments by students:
  - “This course is very hands-on and useful” (2013)
  - “This is an intensive but interesting course” (2013)
  - “The support in the course was a very great help” (2013)
  - “Very good course” (2012)
  - “It’s a very good course” (2012)

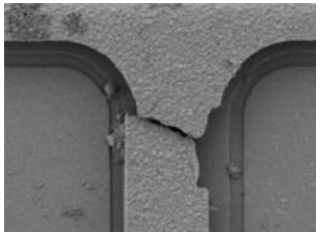
Engineering cycle



1. Problem
2. Idea & concepts
3. Concept verification (simulations)
4. Design (CAD)
5. Fabrication

Implementation

6. Evaluation



7. Concept/design improvements

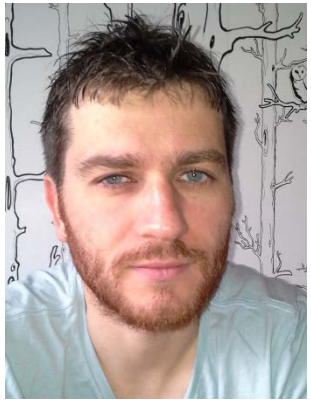
Phases of the project work

1. Introductory meetings (lectures)
2. Design phase
3. Clean-room fabrication phase
4. evaluation phase

(examination)

Joachim Oberhammer (JO)
course responsible, helping out everywhere ...

Bernhard Beuerle (BB)
design supervisor



Stephan Schröder (SS)
fabrication supervisor

Henrik Frid (HF)
evaluation supervisor

Time Schedule EK 2360, 2015

	Phase	Content
Nov 03-06	1	**meetings 1-3** (introduction, MEMS actuators, FEM simulation)
Nov 09-13	2	**design** week 1: concepts, FEM; **meeting 4**: CAD layout, design rules, fabrication
Nov 16-20	2	**design** week 2: FEM simulations, device design
Nov 23-27	2	**design** week 3: device design, CAD layouting
N30-Dec4		**design deadline; intermediate report**
Dec 7-11	3, 4	**fabrication week; evaluation work**
Dec 14-18	4	**evaluation work**
Jan 4-8	(4)	**(evaluation work)**, time for report+presentation writing; **deadline for report**
Jan 12		**final presentation (8-12, Q2)**

ALL IMPORTANT DATES:

- meeting 1 (JO): Time: Monday, Nov. 2, 13:15-15:00, Location: Q11
- meeting 2 (JO): Time: Thursday? Location:
- meeting 3 (BB): Time: Friday?, +training; Location: Lab 1
- meeting 4 (BB+SS): Time: Nov. 12, 16, 17, 20?? ; Location: Lab 1
- progress review meetings: Nov. 16, 23, 27, Lab 1: times for individual groups TBD
- mask layout deadline: Monday, Nov 30, 11:59, Lab 1
- deadline for intermediate report: Sunday, Dec 6, 23:59 (e-mail to JO)
- deadline for final report: Sunday, Jan 11, 23:59 (e-mail to JO)
- project presentations: Monday, Jan 12, 8:15-12:00, Q2, Osq.väg 10, floor 2
  - including **BEST-MOVIE AWARD** competition (not being a part of course grading)

Joachim Oberhammer

Lab 1: A:213 (Osquldas väg 10, floor 2)
Lab 1 is not available: 11/11 AM, 12/11 AM+PM, 25/11 AM, 26/11 AM
Lab 1 is shared with other course: 20/11 AM+PM, 23/11 AM, 24/11 PM, 30/11 AM

1. Introduction meetings

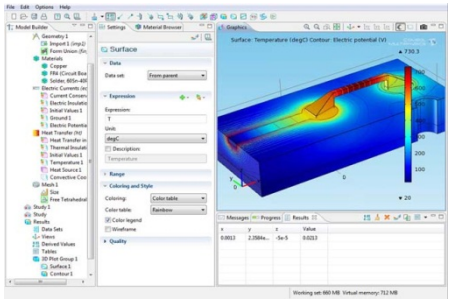
- ***Meeting 1 (week 1):***
  content:
  - course introduction, organizational issues (JO)
  - basics of MEMS, actuators, introduction to MEMS design (JO)
  - decision on follow-up meetings

- ***Meeting 2 (week 1):***
  content:
  - introduction to MEMS design (JO)
  - forming of student groups
  - explanation of task definition, specifications (JO)
  - introduction to the MEMS technology to be utilized in the course (JO)

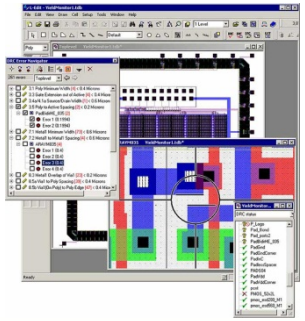
- ***Meeting 3 (end of week 1 or beginning of week 2):***
  content:
  - introduction to FEM modelling (BB)
  - tutorial on COMSOL multiphysics (BB)

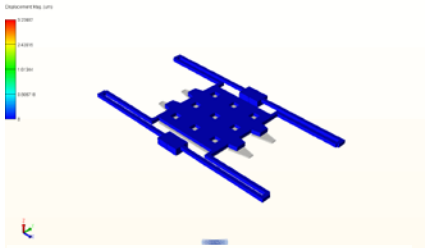
- ***Meeting 4: (end of week 2 or beginning of week 3)***
  content:
  - introduction to LEdit layouting (BB)
  - design rules (BB)
  - introduction to clean-room fabrication, clean-room safety (SS)
  - fabrication process flow (SS)

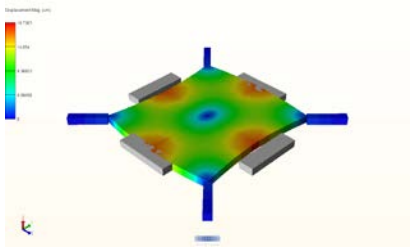
2. Design phase



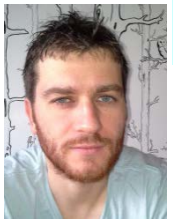
- 3 weeks <u>intensive</u> work
  - device concepts
  - device calculations based on analytical formulas
  - device simulations based on FEM using COMSOL Multiphysics
  - layouting using Tanner LEdit Pro
- progress review meetings every week
- students get access to both software packages for their own computer to work from home
- <u>supervisors:</u> BB, JO
- <u>location:</u> Lab 1, A:213 (Osquldas väg 10, floor 2)







Joachim Oberhammer



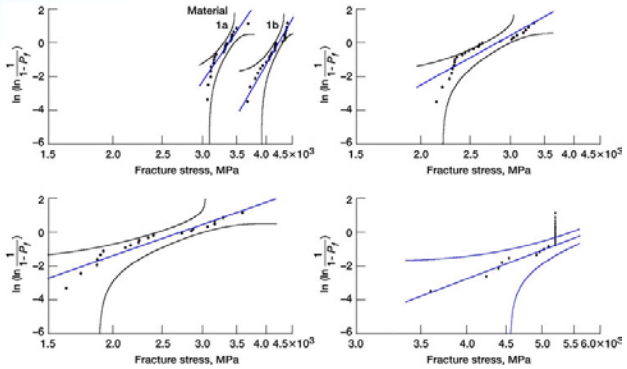
3. Clean-room Fabrication

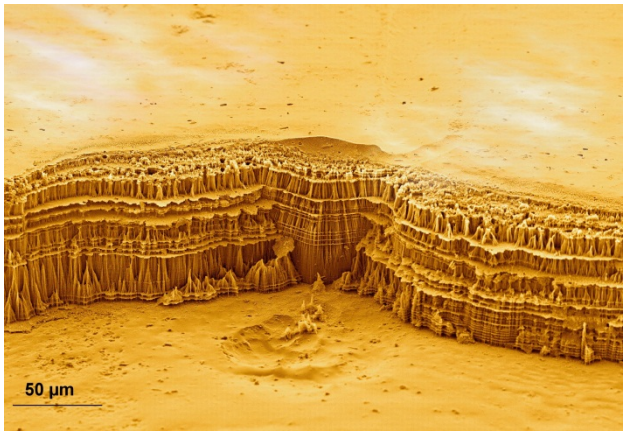
- clean-room fabrication of designed devices by the students (under supervision)
- supervisor: SS
- location: KTH Electrum Laboratory (eLAB), Isafjordsgatan 22-24, Kista
- exact dates/times: to be arranged with fabrication lab supervisors (total of 2-3 full days per group)
- individual, oral test before lab (on lab manual)

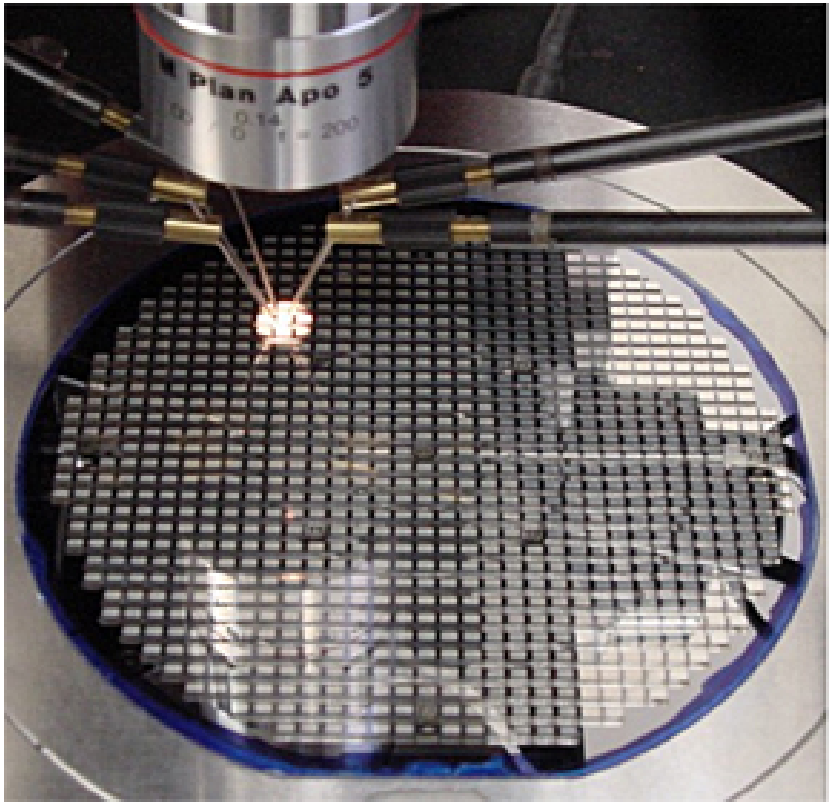
Joachim Oberhammer

4. Characterization

- characterization, evaluation, failure analysis
- location: MST laboratories, Osquldas väg 10, 5th floor
- supervisor: HG
- 2-3 days per group; 1-2 work stations
- individual, oral test before lab (on lab manual)







Joachim Oberhammer

Assessment, examination, feedback

Assessment:

- final mark based on:
  - attendence at compulsory meetings
  - engagement in project work
  - work progress and project achievements
  - deliverables (layouts, reports I+II) at specified deadlines
  - oral tests before fabrication and evaluation lab
  - final presentations
- course grading given by all supervisors: JO, BB, SS, HF

(the Best Movie Award competition is *not* part of the course grading)

Feedback to students:

- continuous feedback through project supervision, in particular progress meetings
- individual written feedback to all students after course completion

Course Material

- course material available at:

KTH Social: https://www.kth.se/social/
log in with your KTH account, select EK2360, select documents

- you must be properly registred to the course for getting access to the course's resources!!

Available on KTH Social:

- EK2360 course material
  - all powerpoint presentations (lectures) necessary
  - course description necessary
  - (fabrication) lab manual necessary
  - (design) tutorials complementing
  - scientific papers complementing
- general MEMS background information complementing

Any Questions

Student Groups 2014

Student group	Name	Fabrication group
1	Giovanni Grandi	A
1	Linnea Gustafsson	A
2	Yizhou Zhang	B
2	Chonmanart Ngampeerapong	B
2	Luca Della Vedona	B
3	Akdik Öner	A
3	Tor Carlsson	A
4 (PhD)	Bernhard Beuerle	-
4 (PhD)	Henrik Frid	-
5 (PhD)	Fritzi Töpfer	-
5 (PhD)	Christos Kolitsidas	B