MICRO-430

Scaling laws in micro- and nanosystems

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Cursus	Sem.	Type
Microtechnics	MA2, MA4	Opt.

Language of teaching	English
Credits	2
Session	Summer
Semester	Spring
Exam	Oral
Workload	60h
Weeks	14
Hours	**2 weekly**
Courses	2 weekly
Number of positions	

Summary

Overview of the dominant physical effects and scaling of laws that applies when downsizing sensors and actuators in microsystems. Show the limits and breakdown of scaling laws in miniaturization. Several examples taken from research articles are presented for each case.

Content

• **Introduction to scaling laws**
Scaling of classical mechanical systems, scaling of classical electrical systems, breakdown in scaling, quantum breakdown

• **Thermal effects**
Conduction, convection, dynamics, breakdown, thermal micro-actuators, microreactors

• **Mechanical devices**
Mass-spring model, mechanical noise, squeeze film effects

• **Electrical devices**
Electrostatic micro-actuators, electrostatic breakdown, tunnel sensors, coils and inductors, electromagnetic micro-actuators, magnetostriction, magnetic beads

• **Microfluidics**
Liquid flow, gas flow, mixing, surface tension, entropy trapping, chromatography

• **Electrokinetics**
Dielectrophresis, EHD and MHD pumps, electrowetting, electroosmosis.

Learning Prerequisites

Recommended courses

Sensors (MICRO-330) very strongly recommended, and content will be assumed to be mastered.

Important concepts to start the course

Students must have a solid mastery of physics (mechanics, heat transfer, eletromagnetism, fluid dynamics), chemistry, and be familiar with MEMS fundamentals (concepts, basic microfabrication) and miniaturized sensors.

Learning Outcomes

By the end of the course, the student must be able to:

- Analyze MEMS devices to determine optimum actuation principle for a given size-scale
- Estimate microsystems performance based on scaling arguments
- Justify choice of sensing or actuation principle
- Exploit scaling to design a MEMS device

Transversal skills

- Access and evaluate appropriate sources of information.

Teaching methods

ex cathedra teaching

Expected student activities

self study, read reference book chapters and papers

Assessment methods

oral exam

Resources

Ressources en bibliothèque

- Fundamentals of microfabrication / Madou
- Micromachined transducers handbook / Kovacs

Prerequisite for

MEMS reliability
Advanced MEMS