MICRO-618 Soft Microsystems Processing and Devices

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Cursus	Sem.	Type
Advanced Manufacturing		Opt.
Microsystems and Microelectronics		Opt.

Language of teaching	English
Credits	2
Session	
Exam	Multiple
Workload	60h
Hours	**27**
Courses	24
TP	3
Number of positions	**16**

Frequency

Every 2 years

Remark

next time February 2028

Summary

Amongst others, following topics will be covered during the course: - Soft Microsystems and Electronics - Electroactive polymers - Printed electronics and microsystems - Inkjet printing of polymers - Stretchable electronics - Mechanical reliability - Stencil lithography - Scanning Probe Lithography

Content

Soft technologies are a complementary evolution of silicon technologies. The use of polymeric and elastomeric materials in combination with dedicated micro and nanofabrication processes is leading to new functionalities and emerging applications. It will have a major impact on several industrial sectors such as consumer goods, environment, energy, logistics, biomedical, health, life-science, transport, safety and security. The objective of the course is to get in depth knowledge and experience on soft devices, materials and processes. The course will cover the main aspects related to polymeric and stretchable microsystems and MEMS, such as materials, design, fabrication process, modelling, testing and reliability.

Structure of the Course:

Introduction to Soft Microsystems and Electronics and conclusion (D. Briand / 3h)

- Introduction to the course objectives, content, program, lecturers, and evaluation
- Overview on soft microsystems and electronics devices and their processing: status, opportunities and challenges
- R&D and commercial status, examples of applications
- Concluding remarks and discussion

Soft actuators for wearable haptics (H. Shea / 3.5h)

This course introduces the principles, technologies, and challenges of soft actuators for wearable haptic systems. Students will learn why haptics matters in VR/AR, teleoperation, rehabilitation, and communication. They will know how human touch perception guides actuator design. We will study two main haptic classes and associated actuators: kinesthetic haptics (force and motion feedback on joints) and cutaneous haptics (tactile skin stimulation). The course emphasizes actuator performance metrics, integration into wearable formats, and emerging fabrication approaches, preparing students to evaluate and design systems that are comfortable, untethered, and effective.

Organic and printed electronics (V. Subramanian / 3.5h)

- Introduction to printed electronics: advantages and disadvantages, comparison and complementarity with Si technology
- Materials: functional inks and substrates
- Additive and large area manufacturing: Printing and curing/sintering techniques
- Examples of printed electronics, optoelectronics, and sensing devices and systems
- Challenges and R&D perspectives

3D structural electronics (D. Briand / 3.5h)

The objective of this lecture is to learn about how electronic functions can be implemented in 3D printed constructs
- Challenges of introducing intelligence in 3D printed structures
- Principles of operation of 3D printing techniques
- Merging 3D & 2D printing techniques to embed electronics in 3D structures
- Methods to integrate discrete components in a 3D printing process flow

Soft micro and nano-processing (J. Brugger / 3.5h)
Micro- and nanofabrication techniques that do not use harsh energy and chemistry to pattern materials at the micro and nanoscale include:
- stencil lithography
- scanning probe lithographies
- self-assembly

In this lecture I will review the fundamentals behind each of these methods and show also the most recent achievements in the field of micro- and nanosystems engineering using soft/polymer based materials. All these techniques are available at EPFL (e.g. CMI) and are directly accessible to PhD students if relevant.

Stretchable electronics (G. Schiavone / 3.5h)
Stretchable electronics is a new evolution of microelectronics. Integrated circuits are no longer constrained to a flat, rigid carrier but rather incorporated within highly deformable carriers thus enabling the circuits to morph, adapting their shape by flexing, stretching or wrinkling.
In this lecture, we will review how materials and fabrication process inspired from those used in microelectronics and MEMS can be implemented to fabricate electronic devices and circuits on soft, skin-like substrates. Further, strategies for the mechanical design ensuring the electromechanical integrity of the stretchable circuits will be presented.
Examples of microfabricated stretchable electronics designed for robotics and prosthetic applications will illustrate the lecture.
- Integrated circuits of arbitrary shapes
a. Examples from academia
b. First steps in industry
- Mechanical strains produced by shaping
- Materials and processes for stretchable electronics
- Electromechanical characterisation

Mechanical reliability (Y. Leterrier / 3.5h)
Soft microsystem and flexible electronic devices are often based on multilayer structures with a very high property contrast between material constituents, yet they should not distort during processing or crack upon bending or stretching. The lecture will present the key factors, which control the mechanical integrity of such structures. It will also provide the essential ingredients to design and produce reliable devices on soft substrates.
- Critical radius and critical strain
- Residual stresses and strains
- Cracking under tensile stress and cohesive properties
- Buckling under compressive stress and adhesive properties
- Test methods and models

Exercices (3h)
The magistral lectures will be complemented by some case studies to be performed by the students.

Learning outcomes

Know the established technologies (commercially available and under development) and the research opportunities in the field, compared with conventional microfabrication and silicon technologies.
Understand the fundamentals of materials for soft microsystems (electroactive polymers, plastic and stretchable electronics).
Understand the fundamentals and practical aspects of processes, printing technologies and device technologies.
Gain knowledge in design approaches and in material and process selection for soft microsystem devices.
Experience demonstrations of selected soft microsystem and flexible electronic devices.
Identify the limitations, challenges and opportunities related to the field.

Keywords

Soft MEMS, Microsystems, Actuators, Flexible and strechable electronics, Printing, Polymer

Learning Prerequisites

Required courses

Background in Semiconductors physics, Electronics, Microsystem Technologies, Microfabrication, and Mechanics of Materials.

Assessment methods

Examination:

Quiz: **Tuesday, March 3rd** from 14h30 to 17h00 in Lausanne (Room PHH331)
Oral Presentations: **Wednesday, March 18th** from 13h to 18h in Lausanne (Room MEB331)

Resources

Moodle Link

- https://go.epfl.ch/MICRO-618