EPFL

MICRO-618

Soft Microsystems Processing and Devices

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

Language of teaching	English
Credits	2
Session	
Exam	Oral
Workload	60h
Hours	**28**
Courses	18
TP	10
Number of positions	**16**

Remark

Online block course - August 31st September 4th 2020 9.15am -5pm

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

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

Electroactive polymers (H. Shea / 3h)

Dielectric elastomer actuators (DEAs) are an emerging actuation technology which is inherent lightweight and compliant, enabling the development of unique and versatile devices with applications ranging from energy harvesting, to soft robotics, to tools for cellular biology, to haptics. The student will learn the basic physical principles of dielectric electroactive polymer actuators, the properties and processing of the elastomers and stretchable electrodes, the control and self-sensing methods, and an overview of different application areas and current research topics.

Organic and printed electronics (V. Subramanian / 3h)

- 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 / 2h)

- Introducing intelligence in 3D printed structures
- 3D printing techniques
- Methods for integration of functionalities

Inkjet printing of polymers (J. Brugger / 3h)

Inkjet Printing is a key enabling technology that goes well beyond the established paper printing. In recent years, novel

areas have matured, where printing techniques find increasingly a pathway from R&D to industrial manufacturing. These areas not only include organic and printed opto-electronics, but also micro-optical, bio-medical, MEMS fabrication and packaging, and 3D rapid prototyping. This lecture will provide an introduction to ink-jet printing technologies in the various existing forms for applications in printed electronics, materials science and life-sciences:
- History of inkjet printing and some examples of equipment
- Methods of producing mono-disperse micro drops: The theory behind drop-on-demand printing. Limits
- Printing of polymers, particularities
- Applications in manufacturing and engineering: SU-8, nano-composites, micro-optics, organic electronic materials, bio-printing, tissue mimetics, etc.

Stretchable electronics (S. Lacour / 3h)

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 / 3h)

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, hands-on (4h)

The magistral lectures will be complemented by exercices, lab visits and hands-on practical work, still to be defined.

Team projects presentations (6h)

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.