MICRO-505

# Organic and printed electronics

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| Cursus | Sem. | Type |
|---|---|---|
| Microtechnics | MA2, MA4 | Opt. |
| Photonics minor | E | Opt. |
| Robotics | MA2, MA4 | Opt. |

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|---|---|
| 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

This course addresses the implementation of organic and printed electronics technologies using large area manufacturing techniques. It will provide knowledge on materials, printing techniques, devices, systems, and applications: state of the art and current status on commercialization.

## Content

**General introduction**: What is printing? Historical background, Printed electronics and large area manufacturing: materials, processes, devices and systems, Unique aspects of printable electronics, Status in the field and trends.
**Organic semiconductors:** Introduction to organic semiconductors, From chemical bonds to bands, Charge injection and transport, Optical properties, Examples of relevant printable electronic and functional materials.
**Printing and other large area processes:** Basics and fundamentals,Fluid formulation and rheology for pritning, Ink-substrate interaction, Inks and printing techniques: gravure, flexography, screen, inkjet, Coating techniques, Laser processes, Additional coating and structuring techniques. Ink drying, curing and sintering: oven, UV, plasma, microwave, photonic techniques.
**Electrons to light and light to electrons: OLEDs and OPVs:** Introduction and history: organic light emitting diodes and organic photovoltaics, Basic device structures and operation, Processing: evaporation/ solution processing, lab to fab, sheet and roll processes, Packaging and encapsulation considerations, Figures of merit and relation to applications.
**Energy storage and harvesting:** Principles of battery and supercapacitors, architectures, printed of energy sources and storage components, Mechanical and thermal harvesters, rectennas.
**Sensors and actuators:** Printed sensors and Actuators, Chemical: liquid and gas phase, Biosensors, Physical sensors: temperature, pressure and touch, light, Microsystems and MEMS, Actuators, Lab-on-chip and microfluidics.
**TFTs and circuits:** Introduction about printed transistors: organic/polymer, metal-oxide, electrolyte gated. CSEM’s case studies: submicrometer OTFTs and gravure printed OTFTs, From transistors to circuits (modeling, design kit, technology assessment).
**Heterogeneous integration and Smart systems:** Introduction to integration methods: one Foil vs. Foil-to-Foil approaches, System in Foil, Hybrid integration: SMD and printed component on foil, CSEM’s case studies: high-pass audio filter and sun sensor, Passive components: Resistors, capacitors, inductors, Memories: Resistive, ferroelectric, write-once-read-many (WORM), RFID, wireless and smart systems.
**Encapsulation:**Introduction, relevance, encapsulation of large area printed / organic electronics, Permeation in solids and thin films, Examples of barriers materials and processing for different devices and systems, Characterization and evaluation of encapsulation.
**Large area manufacturing of printed systems**: Challenges: from small to large area, All printed vs. hybrid, Sheet to sheet vs. roll to roll, Examples of manufacturing lines, Characterization techniques for LAM, Environmental aspects.
**Applications, commercial products and market, roadmap and innovation:** Roadmapping : what is it?, Application examples ( e.g. OLED, OPV, hybrid and integrated systems), Innovation management in printed electronics.

## Keywords

Printed, flexible and organic electronics, large area manufacturing techniques, electronics, photonics, sensors and microsystems, energy sources and storage, encapsulation, heterogeneous integration, smart systems, industrial products

## Learning Outcomes

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

- Illustrate applications of functional and intelligent surfaces and smart systems fabricated using large area manufacturing
- Predict systems integration issues and propose methods for integration and encapsulation of printed devices and systems
- Identify the advantages, drawbacks, performances, complementarity and uniqueness of large area manufacturing vs. silicon technology
- Integrate the operation principles, architectures and processing of main devices and systems fabricated using printing techniques
- Analyze the challenges of manufacturing products using large area fabrication techniques
- Compose exemples of pilot and production lines for printed electronics devices and systems

## Teaching methods

Lectures, exercises, case studies

## Expected student activities

Attending the lectures
Review the slides and read the reference book
Solving the exercises

## Assessment methods

Oral examination at the end of the course

## Resources

### Bibliography

- Organic and Printed Electronics: Fundamentals and Applications, G. Nisato, D. Lupo, S. Ganz (Editors), CRC Press, 2016, 580 pp.
- Large Area and Flexible Electronics, Mario Caironi & Yong-Young Noh (Eds.), WILEY-VCH, 2015, 592 pp.
- Introduction to Printed Electroncis, Katsuaki Suganuma, Springer 2014, 124 p.
- Flexible Electronics: Materials and Applications, W. S. Wong, A. Salleo (Eds.), Springer, 2009, 462 p.
- Organic Electronics II: More Materials and Applications, Hagen Klauk (Ed.), WILEY-VCH, 2012, 420 p.
- Organic Electronics, Hagen Klauk (Ed.), WILEY-VCH, 2006, 428 p.

### Ressources en bibliothèque

- Organic and Printed Electronics: Fundamentals and Applications / Nisato
- Introduction to Printed Electroncis / Suganuma
- Large Area and Flexible Electronics / Caironi
- Organic Electronics: Materials, manufacturing and applications / Klauk
- Organic Electronics II: More Materials and Applications / Klauk
- Flexible Electronics: Materials and Applications / Wong