MICRO-504 **Photonic micro- and nanosystems**

Quack Niels

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

This course aims at providing engineering and design guidelines for selected Photonic Micro- and Nanosystems. In particular, Optical MEMS and Integrated Photonics are reviewed. Standard fabrication processes and related design approaches are introduced and product aspects are discussed.

Content

- **Introduction:** Course Overview, Definitions, Review of Relevant Optics, MEMS/NEMS Fabrication Technologies.
- **Micromirrors:** Reflective Coatings, Distributed Bragg Reflectors, High Contrast Gratings; Piston and Tilting Micromirrors; Mechanical and Optical Design Constraints; Scanning and Projection Systems based on Micromirrors; Design Tradeoffs (Tilt Angle, Size, Speed, Resolvable Spots, Loss Mechanisms). Micromirror Imperfections.
- **Spatial Light Modulators:** Technologies, Amplitude and Phase Modulation, Performance and Applications; Deformable Mirrors; Liquid Crystal, MEMS, Grating Light Valve (GLV), Magneto-Optic, Optical Phased Arrays.
- **Photonic Switches:** Telecommunication Applications, Definition of Key Performance Figures, 2D Switches, Optical Cross Connects, Integrated Photonic Switches.
- **Tunable Lasers:** Tuning Mechanisms and Configurations, Design and Performance (Power, Tuning Range, Linewidth, Response Time).
- **Microspectrometers:** Dispersive Systems, Gratings, FTIR, Fabry Pérot Filters, Hyperspectral Imagers.
- **Silicon Photonics:** Platforms and 'Standard' Fabrication Processes, Passive Components (Waveguides, Transitions, Interferometers, Resonators, Filters, …), Active Components (Sources, Modulators, Detectors), Optical I/O (Grating Couplers, Edge Couplers, Direct Source Coupling).
- **Integrated Photonic Systems:** Promise of Integration; Transceivers and LIDAR-on-Chip System Examples.
- **Engineering Approaches for Photonic Micro- and Nanosystems:** Process and Design, Fab vs. Fabless, Commercially Available Standard Processes (MPW, MOSIS, PIC Foundries), Design Tool Examples, Pricing, Scheduling.
- **Photonic System Packaging:** Assembly Strategies, Interfaces: Optical, Electrical, Thermal, Mechanical.
- **Global Trends:** Photonic Micro- & Nanosystems for Telecom, Datacenters and High Performance Computing.

Keywords

Optical MEMS, MOEMS, Silicon Photonics, Microspectrometers, Spatial Light Modulators.

Learning Prerequisites

Required courses

- Micro-331 – Technologie des Microstructures I (or equivalent)

Recommended courses

- Micro-321, 322 – Ingénierie Optique (or equivalent)
- Micro-330 – Capteurs
- Micro-431 – Microstructures Technology II

Important concepts to start the course

- Microfabrication Techniques
- Optics Basics

Learning Outcomes

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

- Explain the working principle of the discussed photonic micro- and nanosystems
- Analyze a given photonic microsystem with respect to its design constraints
- Discuss potential fabrication processes for a given photonic microsystem
- Propose a design for a photonic microsystem
- Assess / Evaluate design tradeoffs for miniaturized optical systems
- Propose a design for a silicon photonic integrated circuit

Teaching methods

The lecture will be given ex cathedra. Exercices and design examples will be discussed for selected systems. Short experiments will demonstrate selected particularities of spatial light modulators. A selection of scientific papers will be distributed and discussed.

Expected student activities

Attend lectures, read the course material, participate actively during discussions.

Assessment methods

Oral examination at the end of the course.

Resources

Bibliography

- **Fundamentals of Photonics** by B.E.A. Saleh & M.C. Teich, 2007, Wiley
- **Photonic Microsystems** by O. Solgaard, 2009, Springer (MEMS Reference Shelf)
- **MOEMS Micro-Opto-Electro-Mechanical Systems** by M. E. Motamedi, 2005, SPIE
- **Silicon Photonics** by L. Chrostowsky & M. Hochberg, 2015, Cambridge
- **Spatial Light Modulator Technology** by U. Efron, 1995, CRC Press

Ressources en bibliothèque

- Fundamentals of Photonics / Saleh
- Spatial Light Modulator Technology / Efron
- Silicon Photonics Design / Chrostowsky
- Photonic Microsystems / Solgaard
- MOEMS Micro-Opto-Electro-Mechanical Systems / Motamed

Notes/Handbook

Lecture powerpoint slides will be available to download via moodle before each class.

Moodle Link

- http://moodle.epfl.ch/enrol/index.php?id=15338