EPFL

MICRO-516

Nanophotonics

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Cursus	Sem.	Type
Electrical and Electronical Engineering	MA2, MA4	Opt.
Microtechnics	MA2, MA4	Opt.
Photonics minor	E	Opt.

Language of teaching	English
Credits	3
Session	Summer
Semester	Spring
Exam	Oral
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

Students understand and apply the physics of the interaction of light with semiconductors. They understand the operating mechanism of scaled photonic devices such as photodetectors, LEDs and lasers, as well as challenges and opportunities relating to their integration and dimensional scaling.

Content

Significant parts of the theoretical foundation of this course is similar to integrated photonics in general. The focus, however, will be on applying this to applications and dimensionally scaled devices (such as nanowire devices, micro-cavities, single photon devices etc.) and in particular the specific challenges which relates to integrating the materials, device processing and performance in such structures. In most lectures we will first introduce the required theory and then discuss different applications, useful materials classes, and state-of-the-art implementations from literature.

Topics covered:

- Dielectric waveguides and couplers
- Photonic Crystals and meta-materials
- Photonic materials: Â III-V, III-nitrides, group-IV, 2D materials, perovskites.
- Role of quantization and strain in photonic device integration
- Interaction of light with semiconductors
- Photo-detectors
- LEDs and lasers
- Nanolasers, Micro- and Nanoresonators
- Electro-optic modulators and phase modulation, LiNb, BTO, electro-absorption modulators.
- Applications of plasmonics for scaled photonic devices
- Single Photon devices and QD emitters, SPADs, superconducting nanowire detectors

For all of these topics we consider state-of-the-art embodiments, along with challenges relating to materials and device integration, as well as efficient light coupling in and out of these scaled devices.

Learning Prerequisites

Required courses

An understanding of solid-state physics is required; in particular, the students must be familiar with semiconductors, energy band diagrams, Fermi distribution and density of states for bulk and quantized structures. Other courses in MI or Physics might have similar content so the students should avoid overlap. The scope of the course is broad, so other classes which go into more detail on individual devices such as lasers or detectors may complement it.

Important concepts to start the course

The students must be familiar with basic solid-state physics, semiconductors and band diagrams. Otherwise it will not be possible to follow.

Learning Outcomes

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

- Describe the physical mechanisms behind the interaction of light with semiconductors and other materials, such as absorption and emission of light as well as electro-optic modulation and how it is pendent on the material properties.
- Identify which material properties are appropriate to achieve different optical functions in a given wavelength regime.
- Assess / Evaluate different mechanisms for light detection in solid-state devices, such as pin and avalanche photodiodes or super-conducting nanowire single photon detectors.
- Explain the basics of light emission in semiconductors for LEDs and Lasers, and evaluate the trade-offs between different cavity designs such as whispering gallery, Fabry-perot or photonic crystal structures.
- Assess / Evaluate how dimensionality and scaling affects photonic devices. Be able to describe the effect of quantum wells, quantum dots and low dimensional materials in photonic applications

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Teaching methods

Classroom teaching and exercises. Wewill try to have presentations by two external comapnies during the semester

Expected student activities

Active praticipation in class in terms of polls and questions

Assessment methods

Oral exam accounts for 100% of grade.

Supervision

Office hours	No
Assistants	Yes

Resources

Bibliography

In this course we will use the book: "Fundamentals of Photonics", by B.E.A Saleh and M.C. Teich, 3rd edition (different from 1st and 2nd edition). We will principally use volume 2: Photonics.
Additionally select other material will be used to complement the individual topics.

Ressources en bibliothèque

- Fundamentals of Photonics / Saleh, Teich

Moodle Link

- https://go.epfl.ch/MICRO-516