230564 - NANO – Nanophotonics

Coordinating unit: 230 - ETSETB Barcelona School of Telecommunications Engineering
Teaching unit: 893 - ICFO - Institute of Photonic Sciences
Academic year: 2015 - 2016
Degree: Master's Degree in Photonics
Erasmus Mundus Master's Degree in Photonics Engineering, Nanophotonics and Biophotonics
ECTS credits: 3 **Teaching languages:** English

Academic staff

Coordinator: Niek van Hulst (ICFO) niek.vanhulst@icfo.es
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Degree competences to which the subject contributes

Transversal:
1. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
2. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.
3. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.
4. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Teaching methodology

Lectures
Experimental sessions

Objectives and short description of the course

Nanophotonics is where optics and nanotechnology meet. NanoPhotonics plays an important role in current (and future) ultra-small and ultra-sensitive detection, (nano)imaging, light-capture, emission control, quantum-optics, optical circuitry, data storage. Both fundamental concepts and applications will be treated in details.

Study load

Total learning time: 75h	Hours large group:	22.5h	30%
	Hours medium group:	0h	0%
	Hours small group:	0h	0%
	Guided activity:	2.25h	3%
	Self study:	50.25h	67%

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Course index

1. **Basic concepts:** different regimes of optics; far-field versus near field, evanescent waves; optical response of a sub-wavelength objects; diffraction limit; imaginary wavevectors.

2. **Fabrication of nanophotonic structures:** top-down (photo-litho, e-beam, FIB, nano-inprint); bottom-up (colloids synthesis, self-assembly, coordination chemistry).

3. **Optical adressing the nanoscale:** confocal microscopy, scanning probe microscopy, near field microscopy, non-linear microscopy, nano-antennas, antenna-nanoscopy, single emitter probing.

4. **Plasmonics**: optical properties of metals (dielectric function, extended plasmons versus particle plasmons), individual and coupled metallic nanoparticles with plasmonic resonances for local field enhancement, extraordinary optical transmission through holes, bio-chemical sensing, nanoscale microscopy, enhanced radiative decay, enhanced Raman, etc.

5. **Single photon emitters**: nanoparticles, molecules, quantum, diamond NV-centers, quantum jumps, photon statistics, (anti)bunching, coupling to antennas, decay rate engineering.

6. **NanoPhotonic wires:** molecular complexes, excitonic systems, nanoscale energy transfer, coherent energy transfer, fs coherent control.

7. **NanoPhotonics with 2D materials**: graphene band stricture, doping; graphene plasmonics.

8. **Light scattering** by nano-particles, photonic crystals and circular nano/micro-resonators. Applications of WGM resonators: Sensing, Non-linear optics.

9. **Nanophotonics applied to thin film Solar cells:** Solar cells: basic concepts. Light management using photonics crystals and plasmonic particles to enhance solar cell performance. Nano/micro-fiber array solar cells.

10. **Nonlinear Nanophotonics:** Second and third order nonlinear interaction within photonic structures (ordered and disordered), Metal nanoparticles and quadratic nonlinear optics.

11. **Applications in biology, materials science, telecom and photonics.**

Qualification system

Exam and/or presentation (70%)
Attending and active participation in class (30%)

Bibliography

- Lukas Novotny & Bert Hecht, “NanoOptics”, Cambridge University Press.