Course guide
230564 - NANO - Nanophotonics

Last modified: 14/12/2023

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 893 - ICFO - Institute of Photonic Sciences.

Degree: MASTER'S DEGREE IN PHOTONICS (Syllabus 2013). (Optional subject).

Academic year: 2023 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE2. Demonstrate the understanding of the peculiarities of the quantum model for light-matter interaction.
CE4. Demonstrate knowledge of the fundamentals of image formation, propagation of light through different media and Fourier Optics.
CE9. Ability to synthesize and present photonics research results according to the procedures and conventions of scientific presentations in English.

Generical:
CG1. Ability to project, design and implement products, processes, services and facilities in some areas of photonics, such as photonic engineering, nanophotonics, quantum optics, telecommunications and biophotonics.

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. 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.

3. 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.

CT3. TEAMWORK. Be able to work as a member of an interdisciplinary team, either as another member, or performing management tasks in order to contribute to developing projects with pragmatism and a sense of responsibility, assuming commitments taking into account the available resources.

Basic:
CB6. Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context
CB7. Students should know how to apply the knowledge acquired and their problem-solving ability in new or little-known environments within broader (or multidisciplinary) contexts related to their area of ¿¿study.
CB8. Students should be able to integrate knowledge and face the complexity of formulating judgments based on information that, being incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgment.
CB10. Students should possess the learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.

TEACHING METHODOLOGY

- Lectures
- Activities

LEARNING OBJECTIVES OF THE SUBJECT

NanoPhotonics is where optics and nanotechnology meet. NanoPhotonics plays an important role in current (and future) ultra-small and ultra-sensitive sensing, imaging, optical circuitry, data storage. Both fundamental concepts and applications will be treated in details.

STUDY LOAD

Type	Hours	Percentage
Hours large group	24,0	32.00
Self study	51,0	68.00

Total learning time: 75 h

CONTENTS

1- Basic concepts

Description:
Different regimes of optics; far-field versus near field, evanescent waves; optical response of a sub-wavelength objects; diffraction limit; imaginary wavevectors.

Full-or-part-time: 4h 30m
Theory classes: 4h 30m

2- Fabrication of nanophotonic structures

Description:
Top-down (photo-litho, e-beam, FIB, nano-inprint); bottom-up (colloids synthesis, self-assembly, coordination chemistry).

Full-or-part-time: 1h
Theory classes: 1h

3- Optical adressing the nanoscale

Description:
Confocal microscopy, scanning probe microscopy, near field microscopy, non-linear microscopy, nano-antennas, antenna-nanoscopy, single emitter probing.

Full-or-part-time: 2h
Theory classes: 2h

4- Plasmonics

Description:
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.

Full-or-part-time: 3h
Theory classes: 3h

5- Single photon emitters

Description:
Nanoparticles, molecules, quantum, diamond NV-centers, quantum jumps, photon statistics, (anti)bunching, coupling to antennas, decay rate engineering.

Full-or-part-time: 2h
Theory classes: 2h

6- NanoPhotonic wires

Description:
Molecular complexes, excitonic systems, nanoscale energy transfer, coherent energy transfer, fs coherent control.

Full-or-part-time: 1h
Theory classes: 1h

7- NanoPhotonics with 2D materials

Description:
Graphene band structure, doping; graphene plasmonics.

Full-or-part-time: 3h
Theory classes: 3h

8- Light scattering

Description:
By nano-particles, photonic crystals and circular nano/micro-resonators. Applications of WGM resonators: Sensing, Non-linear optics.

Full-or-part-time: 1h
Theory classes: 1h

9- Nanophotonics applied to thin film Solar cells

Description:
Solar cells: basic concepts. Light management using photonics crystals and plasmonic particles to enhance solar cell performance. Nano/micro-fiber array solar cells.

Full-or-part-time: 2h
Theory classes: 2h

10- Nonlinear Nanophotonics

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

Full-or-part-time: 1h
Theory classes: 1h

11- Applications

Description:
Biology, materials science, telecom and photonics.

Full-or-part-time: 2h
Theory classes: 2h

GRADING SYSTEM

- Exam (55%)
- Presentation (35%)
- Attending and active participation in class (10%)

BIBLIOGRAPHY

Basic:
- Novotny, L.; Hecht, B. Principles of nano-optics. 2nd ed. Cambridge: Cambridge University Press, 2012. ISBN 9781107005464.