Course guides
230564 - NANO - Nanophotonics

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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).
ERASMUS MUNDUS MASTER'S DEGREE IN PHOTONICS ENGINEERING, NANOPHOTONICS AND BIOPHOTONICS (Syllabus 2010). (Optional subject).

Academic year: 2020 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Niek van Hulst (ICFO)

Others: Romain Quidant (ICFO)
Frank Koppens (ICFO)
Jordi Martorell (ICFO)

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE2. (ENG) Màster en Fotònica:
Demostrar que comprende las peculiaridades que comporta el modelo cuántico para la interacción luz-materia.
CE4. (ENG) Màster en Fotònica:
Demostrar que conoce los fundamentos de la formación de imagen, de la propagación de la luz a través de los diferentes medios y de la Óptica de Fourier.
CE9. (ENG) Màster en Fotònica:
Capacidad para sintetizar y exponer los resultados de investigación en fótonica según los procedimientos y convenciones de las presentaciones científicas en inglés.

Generical:
CG1. (ENG) Màster en Fotònica:
Capacidad para proyectar, diseñar e implantar productos, procesos, servicios e instalaciones en algunos ámbitos de la fotónica como los relacionados con la ingeniería fotónica, la nanofotónica, la óptica cuántica, las telecomunicaciones y la biofotónica

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. (ENG) Màster en Fotònica:
TRABAJO EN EQUIPO. Ser capaz de trabajar como miembro de un equipo interdisciplinar ya sea como un miembro más, o realizando tareas de dirección con la finalidad de contribuir a desarrollar proyectos con pragmatismo y sentido de la responsabilidad, asumiendo compromisos teniendo en cuenta los recursos disponibles

Basic:
CB6. (ENG) Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación
CB7. (ENG) Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.
CB8. (ENG) Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicio.
CB10. (ENG) Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

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

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

BIBLIOGRAPHY

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