Course guide
230562 - MATMETA - Photonics Materials and Metamaterials

Last modified: 11/04/2025

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 1004 - UB - (ENG)Universitat de Barcelona.

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

Academic year: 2025 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: RAMON HERRERO SIMON

Others: Primer quadrimestre:
BLAS GARRIDO FERNÁNDEZ - 10
RAMON HERRERO SIMON - 10

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.

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.

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

LEARNING OBJECTIVES OF THE SUBJECT

"Photonic materials and metamaterials" aims to introduce to the chemical and physical properties of the most important material platforms in photonics. The emphasis is in studying optical and electro-optical properties which will be related with the more fundamental material characteristics such as composition, bonding, electronic structure and doping. These fundamental properties will serve to describe and understand the physics and technology of a variety of photonic and optoelectronic structures related with lasing, photovoltaics, waveguiding and non-linear optics.

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. Crystal structure and optical processes in solids.

Description:
1.1 Bulk structure, electronic levels and defects.
1.2 Elementary excitations in solids: excitons and phonons.
1.3 Optical properties of semiconductor materials.

Full-or-part-time: 7h 30m
Theory classes: 7h 30m

2. Functional photonic materials.

Description:
2.1 Low dimensional materials: quantum wells, wires and dots.
2.2 Solid-State-Laser materials.
2.3 Materials and structures for solid state lighting and photovoltaic applications.

Full-or-part-time: 7h 30m
Theory classes: 7h 30m

3. Photonic extend material structure

Description:
3.1 Photonic crystals: dimensionality, photonic band structure and defects.
3.2 Linear and non-linear properties of photonic crystal structures.
3.3 Metamaterials: electric and magnetic, negative-index.
3.4 Properties and applications of metamaterials.

Full-or-part-time: 7h 30m
Theory classes: 7h 30m

ACTIVITIES

Activity

Full-or-part-time: 2h 18m
Theory classes: 2h 18m

GRADING SYSTEM

· Evaluation of the presentation on a subject of the lectures (50%).
· Evaluation of the global examination (50%).

BIBLIOGRAPHY

Basic:

- Saleh, B.E.A.; Teich, M.C. Fundamentals of photonics. 3rd ed. Hoboken: John Wiley & Sons, 2019. ISBN 9781119506874.
- Kalt, H.; Klingshim, C.F. Semiconductor optics 1: linear optical properties of semiconductors. 5th ed. Cham: Springer, 2019. ISBN 9783030241506.
- Korvink, J.G.; Greiner, A. Semiconductors for micro and nanotechnology: an introduction for engineers. Wiley-Vch, 2002. ISBN 9783527302574.
- Fukuda, M. Optical semiconductor devices. John Wiley & Sons, 1999. ISBN 0471149594.
- Steiner, T. Semiconductors nanostructures for optoelectronic applications. Artech House, 2004. ISBN 9781580537513.