Course guide
230573 - MEASUR - Measuring with Light

Last modified: 19/06/2024

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 731 - OO - Department of Optics and Optometry.

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

Academic year: 2024 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Consultar aquí / See here:

Others: Consultar aquí / See here:

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE3. Know the fundamentals of laser physics, the types of lasers and their main applications.
CE4. Demonstrate knowledge of the fundamentals of image formation, propagation of light through different media and Fourier Optics.
CE7. Ability to understand optical engineering as an economic and business activity considering, among others, social, ethical and sustainability aspects
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.
CG2. Ability to modeling, calculate, simulate, develop and implement in research and technological centers and companies, particularly in research, development and innovation tasks in all areas related to Photonics.
CG4. Ability to understand the generalist and multidisciplinary nature of photonics, seeing its application, for example, to medicine, biology, energy, communications or industry

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
- Activities

LEARNING OBJECTIVES OF THE SUBJECT

Harnessing light for the measurement of real world phenomena offers a variety of different techniques and methodologies. Different setups and approaches provide paths for the characterization of surface shapes, hidden defects, optical aberrations or material properties. Noncontact in nature, a variety of working principles (from geometrical, Fourier and physical optics) allows covering a broad range of applications both in research, medicine and in industry.
Optical metrology techniques are general tools which can be useful to both lab scientists and application engineers. However, only the most basic techniques are usually presented in general undergraduate. In our subject students will be provided with theoretical, practical and hands-on experience on the basic principles of a selection of the most relevant optical metrology techniques. They will also briefly peek inside experimental and numerical techniques which boost the performance of several of them. We will review the different major families of techniques and applications while presenting to the student the most relevant applications of each technique in the industrial and research arenas.

BIBLIOGRAPHY:
· Basic
· Malacara, D. (1992). 'Optical shop testing'. 3rd ed. New York : John Wiley & Sons. ISBN: 0471522325
· Gasvik, K.J. (2002). 'Optical metrology'. 3rd ed. Chichester : John Wiley & Sons. ISBN:9780470843000
· Mercer, C. (2003) 'Optical metrology for fluids, combustion and solids' Kluwer Academic Publishers ISBN:1402074077
· Rastogi, P.K. (1997). 'Optical measurement techniques and applications'. Boston: Artech House. ISBN: 089006516
· Advanced
· Min Gu "Advanced optical imaging theory", Springer Series in Optical Sciences 75, Springer-Verlag ISBN 9783540662624
· Surface Texture (Surface Roughness, Waviness, and Lay), ANSI/ASME Standard B46.1-1995

Updated topical specific bibliography and teaching materials will be distributed through the ATENEA web platform.

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. Introduction

Description:
1.1 Basic concepts involved in optical surface metrology.
1.2 Surface characterization: shape and texture.
1.3 General overview of surface metrology techniques.

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

2. Single point techniques

Description:
2.1. Triangulation techniques.
2.2. Confocal and chromatic confocal.
2.3. Single point interferometry.
2.4. Self-mixing interferometry.
2.5. Time of flight imaging. Lidar. Ladar.

Full-or-part-time: 6h
Theory classes: 6h

3. Imaging techniques

Description:
3.1. Imaging in high numerical aperture conditions.
3.2. Noninterferometric wavefront sensing.
3.3. Wavefront fitting techniques.
3.4. Fringe projection techniques.
3.5. Phase-shifting techniques.
3.6. Confocal profilometry.
3.7. Interferometric imaging.
3.8. Profilometry of stratified media.
3.9. Optical metrology of laser induced photonics structures
3.9.1. Methods for refractive index profilometry
3.9.2. Characterization of propagation losses in laser written waveguides.
3.9.3. Metrology of laser-induced photonics structures
3.10. Polarimetry
3.9.1. Applications
3.9.2. Polarization state generators, and analyzers. Mathematical description of Stokes polarimeters
3.9.3. Classes of polarimeters. Optimization of polarimeters
3.11. Computer generated holograms in Optical testing
3.9.1. Computer generated holograms (CGHs)
3.9.2. Plotting CGHs
3.9.3. Interferometers using CGHs

Full-or-part-time: 14h 30m
Theory classes: 14h 30m

ACTIVITIES

Activity

Description:
- A practical session showing some of the most relevant techniques included the course contents will be held, with an estimated duration of 4 hours.
- Seminars based on the contents of the course may be included in the subject, depending on availability of relevant speakers.

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

GRADING SYSTEM

- A personal written exam at the end of the course including all contents with a weight of 60%.
- A number of deliverables and exercises based on the topics of the course distributed at the end of some sessions, in order to work the contents of the session (40%)
- Optionally, students may present one report describing the basics and development of the practical session of the subject, for a 10% weight. For the students choosing this option the weight of the exam is reduced to 50%.

BIBLIOGRAPHY

Basic:
- Malacara, D. Optical shop testing. 3rd ed. New York [etc.]: John Wiley & Sons, 2007. ISBN 9780471484042.
- Rastogi, P.K. Optical measurement techniques and applications. Boston: Artech House, 1997. ISBN 0890065160.
- Gåsvik, Kjell J. Optical metrology. 3rd ed. Chichester [etc.]: John Wiley, 2002. ISBN 0470843004.
- Mercer, Carolyn R. Optical metrology for fluids, combustion, and solids. Boston: Kluwer Academic, 2003. ISBN 1402074077.
- American Society of Mechanical Engineers. Surface texture : surface roughness, waviness and lay. American Society of Mechanical Engineers, 2009. ISBN 9780791832622.

Complementary:
- Gu, Min. Advanced optical imaging theory. Berlin: Springer, 2000. ISBN 3540662626.