230573 - MEASUR - Measuring with Light

Coordinating unit: 230 - ETSETB Barcelona School of Telecommunications Engineering
Teaching unit: 731 - OO - Department of Optics and Optometry
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: Santiago Royo (UPC) santiago.royo@upc.edu
Other professors: Ferran Laguarta (UPC) laguarta@oo.upc.edu
Juan Campos (UAB) juan.campos@uab.cat

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
Activities:
- A practical session showing some of the most relevant techniques included in 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.

Objectives and short description of the course

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 courses. Here 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

230573 - MEASUR - Measuring with Light

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.

A general background in physics and/or engineering is recommended for maximum profit of the course, but not strictly required.

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%

Course index

1. Introduction

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

2. Single point techniques

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.

3. Imaging techniques

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

230573 - MEASUR - Measuring with Light

3.10 Polarimetry
- 3.10.1 Applications
- 3.10.2 Polarization state generators, and analyzers. Mathematical description of Stokes polarimeters
- 3.10.3 Classes of polarimeters. Optimization of polarimeters

3.11 Computer generated holograms in Optical testing
- 3.11.1 Computer generated holograms (CGHs)
- 3.11.2 Plotting CGHs
- 3.11.3 Interferometers using CGHs

Qualification 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. (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