UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# COURSE SYLLABUS

# Optical Spectroscopy of Solids

**2526-1-F1703Q031**

## Aims

The main goal of the course is giving the tools for the description and measurement of the optical properties of solids, to complete the overall picture of solid state physics.

Specific aims of the course:

- discussing light propagation in solids
- introducing the proper concepts and physical quantities for the description of the optical properties of solids
- discussing the characteristic optical properties of different solid materials
- illustrating the main optical spectroscopy techniques and the working principles of instruments

By attending the lectures and successfully passing the exam, the student will have developed a solid understanding of the fundamental principles governing the propagation of light in various media (knowledge and understanding), as well as of the interface phenomena that form the basis for the study and implementation of experimental techniques (applying knowledge and understanding). The student will be able to critically assess and select the most appropriate methods for carrying out basic measurements (making judgements), and will be proficient in employing precise and rigorous scientific language to effectively communicate the acquired knowledge (communication skills).

## Contents

- Dielectric response of solids

- Interfaces, thin films and optical spectroscopy

- Instruments and techniques for optical spectroscopy

## Detailed program

**Dielectric response of solids**
References to Maxwell's equations in vacuum and in the matter; wave equation; electromagnetic spectrum. The propagation of light in the matter; complex dielectric function and refractive index; dielectric tensor and anisotropy; wave equation in anisotropic media. Microscopic origin of the dielectric response; Lorentz and Drude models; dispersion relations, Kramers-Kronig relations, screen effects, local field, Lorentz-Lorenz and Clausius-Mossotti equations. Cauchy and Sellmeier models; effective medium theories. Semi-classical model for the dieletric response. Typical response of dielectrics, metals, semiconductors. Non linear optical response (elements).

**Spectroscopy**
Interfaces, Fresnel coefficient, T e R at normal incidence; Brewster angle. Total internal reflection, evanescent wave. Thick slabs and thin films; transparent, absorption, anisotropic film; film on a substrate. Multilple interfaces, multilayers and matrix method.

**Techniques and instrumentation**
Sources, dispersive elements,detectors; principles of Fourier transform instruments; measurements of reflectance, transmittance, absorbance, single and double beam instruments. Polarization of light (recalls). Transmittance and reflectance in polarized light. Jones formalism and principles of spectroscopic ellipsometry. Time-resolved emission and emission spectroscopies. Raman spectroscopy.

## Prerequisites

Classical electromagnetism and basic concepts of structure of matter.

## Teaching form

Lessons and examples.

## Textbook and teaching resource

1. J. Peatross and M. Ware, *Physics of Light and Optics* (2015), available at optics.byu.edu

2. O. Stenzel, *The Physics of Thin Film Optical Spectra* (Springer, 2005)

3. G. Giusfredi, *Manuale di ottica* (Springer, 2015)

4. H. Kuzmany, *Solid State Spectroscopy* (Springer, 2009)

5. M. Fox, *Optical Properties of Solids* (Oxford University Press, 2010)

6. N.V. Tkachenko, *Optical spectroscopy* (Elsevier, 2006)

7. M. Born and E. Wolf, *Principles of Optics* (Pergamon Press, 1989)

8. F. Wooten, *Optical Properties of Solids* (Academic Press, 1972)

9. J. Garcia Solé, L.E. Bausà, and D. Jaque, *An Introduction to the Optical Spectroscopy of Inorganic Solids* (Wiley, 2005)

10. E. Hecht, *Optics* (Addison Wesley, 2002)

See also: The Feynman Lectures on Physics, at www.feynmanlectures.caltech.edu/

NOTE: textbooks 2, 3 and 4 can be downloaded as pdf files from the library website; textbook 1 is also freely available.

## Semester

II semester

## Assessment method

Oral exam.
Discussion about some of the subjects of the lectures, starting from a subject at choice.

Once registered, the students can ask for delaying the exam of a few days. Otherwise, date, hour, and room are the ones published in "segreterie online".

## Office hours

Prof. Sassella is available for meeting the students upon request by e-mail: adele.sassella@unimib.it

## Sustainable Development Goals

QUALITY EDUCATION