



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## SYLLABUS DEL CORSO

### Spettroscopia Ottica dello Stato Solido

2324-1-F1701Q110

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#### 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

#### 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 dielectric 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. Multiple 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 condensed matter physics.

### **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](http://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/](http://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 "segreteria online".

## **Office hours**

Upon request, by e-mail: [adele.sassella@unimib.it](mailto:adele.sassella@unimib.it)

## **Sustainable Development Goals**

QUALITY EDUCATION

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