UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Materials Spectroscopy and Microscopy

2627-1-F1702Q011

Aims

1. Knowledge and understanding:
   The scope of the course is to give the students a general introduction to the main spectroscopy and imagine techniques currently available for material characterization, with a focus on materials with applications in optometry and vision science. For each technique, the following topics will be covered:

- physical properties (what information can be extracted);
- sample compatibility and specimen preparation;
- hardware requirements and complexity;
- data analysis and presentation.

2. Applying knowledge and understanding:
   During this course, students will learn to identify the experimental techniques utilized in scientific research, understanding both their rationale and application limits.

3. Making judgements:
   At the end of the class the students should:

- recognize the techniques applied in a research work;
- be capable of reading and understanding scientific data results on a scientific paper;
- be able to suggest the best techniques in order to tackle a specific research problem;
- know how to properly display scientific data for each technique.

4. Communication skills:
   The student will acquire the specific terminology accompanying each experimental technique, in order to comprehend and coherently report the relevant findings.

5. Learning skill:

The aim of this course is to equip students with the skills necessary to independently explore scientific literature in the fields of materials science and optometry.

Contents

The course will be divided in three sections:
1 – A general introduction, with basic concept of light interaction with matter;
2 – Spectroscopy techniques: UV-VIS, IR/FTIR, Raman, spectroscopic ellipsometry, X-ray based spectroscopies, synchrotron light techniques;
3 – Imaging techniques: standard and superresolution (STED, PALM, STORM) microscopies, SEM/TEM, STM, AFM.
Both spectroscopy and imaging modules will be complemented by a lecture about the corresponding basic data analysis methods.

Detailed program

• Introduction: complex analysis reminders (Fourier transform); fundamental models for light-matter interaction: reflectivity index, Lorentz oscillator model for single resonator, TART diagrams, double level transition time and linewidth.

• Spectroscopy techniques. Experimental setup, methods and application examples with special focus on the materials for optics, optometry, and vision science:
o UV-VIS spectroscopy;
o Raman and IR/FTIR spectroscopy: vibrational modes, methods and application examples;
o Ellipsometry: introduction, experimental setup, material modelling and application examples;
o General introduction to X-rays; overview of X-ray spectroscopies (XRD, XPS, XAS).
o Data analysis methods for spectroscopy data: smoothing, interpolation, convolution/deconvolution filters, noise estimation, spectra matching, curve fitting, data visualization best practice.

• Imaging technique: experimental setup, methods and application with special focus on the materials for optics, optometry, and vision science:
o Overview of microscopy: experimental setup, general concepts;
o Fluorescence microscopies and superresolution techniques (STED/PALM/STORM/SNOM)
o Electron microscopies: SEM and TEM. Experimental setup and sample preparation;
o Rasterization techniques: scanning tunneling microscopy (STM) and atomic force microscopy (AFM).
o Data analysis methods for imaging results: morphological transformations, convolution operators, FFT filtering, contours detection and cluster identification, general statistics evaluation, data visualization guidelines.

Prerequisites

Student requirements match the topics listed in the “Orienteering for Future Students and Admission Procedures”, available on the e-learning platform. Basic mathematical topics will be refreshed on the first course lectures.

Teaching form

42 total lecture time:
• 26 hours of frontal lectures;
• 4 hours of interactive frontal lessons
• 12 hours of remote lectures, recorded

Textbook and teaching resource

Course slides, vide recordings for remote lessons, additional material provided by the teacher.

Semester

second semester

Assessment method

The final exam consists of an oral examination divided into two consecutive parts:

1. Each student is required to agree in advance with the instructor (at least two weeks prior to the exam) on a topic or technique for in-depth study. The presentation of this topic (lasting approximately 20 minutes) will account for 2/3 of the final grade.
2. This will be followed by a few additional questions on the remaining course topics, which will be assessed at a lower level of detail compared to the topic chosen for the first part.

During the exam, students may be asked to evaluate graphs or data extracted from research articles. There are no mid-term exams.
The grading criteria are as follows:
Fail: < 18
Pass: 18–23
Good: 24–27
Very Good: 28–30
Excellent / Outstanding: 30 with honors (30 e lode)

Office hours

by appointment to be arranged via email

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE