EPFL

CH-633 **Advanced Solid State and Surface Characterization**

Mensi Mounir Driss, Oveisi Emad, Schouwink Pascal Alexander

Cursus	Sem.	Type
Chemistry and Chemical Engineering		Opt.

Language of teaching	English
Credits	2
Session	
Exam	Oral
Workload	60h
Hours	**28**
Courses	28
Number of positions	**20**

Frequency

Every 2 years

Remark

Next time: Spring 2021

Summary

State-of-the-art surface/thin film characterization methods of polycrystalline/nano/amorphous materials. Selected topics from thin film X-ray diffraction (GIWAXS, GISAXS, PDF), electronic and optical spectroscopy (XPS, AES, SERS, TERS), scanning probe and electron microscopy (STM, AFM, HRTEM, SEM).

Content

This course aims at summarizing a multitude of state-of-the-art characterization methods for thin films, surfaces and nanomaterials.
Applications of state-of-the-art techniques, both at EPFL facilities and outside, will be covered, providing theoretical bases, relevent topics and examples from current research. The course is aimed at applications in materials science/chemistry and chemical engineering.
The course will consist of four modules, starting with a brief introduction to the physical, electronic and optical properties of the solid-state.

1. X-ray scattering: students will be familiarized with surface sensitive (grazing incidence) diffraction geometries and the data-interpretation of texture and composition on multiple length scales, from the Angstrom range (GIWAXS) up to mesoscopice features of 100s of nm (GISAXS). The principle of X-ray reflectometry in the study of film thickness and composition will be discussed. An introductory outline will be given on the analysis of amorphous materials by means of total scattering and the pair distribution function (PDF). Emphasis will be placed on non-ambient studies.

2. Spectroscopy: following an introduction on optical spectroscopy, vibrational spectroscopy (IR, Raman, SFG) will be treated. The charcherization of graphene using Raman spectroscopy will be emphasized. Near-field optics will then be introduced to serve as a ground for the description surface enhanced Raman spectroscopy.
Electron (Auger) and photoelectron spectroscopy will be presented with a focus on the underlying physico-chemical processes. With a surface sensitivity of few nm, these methods, while extremely sensitive to surface contamination, will reveal their importance for the chemical analysis of surfaces and the identification of chemical states. Guidelines for the preparation and handling of samples will be proposed in order to limit deleterious contamination. Finally, to provide the student with a review of the principal techniques of spectroscopy, an overview on ion and neutral spectroscopy will be presented.

3. Scanning probe microscopy (SPM): the basis of SPM will be outlined starting with theory and application of STM and AFM. The combination of SPM with optical spectroscopy will be discussed (SNOM, TERS). SPM is extensively used to assess surface morphology and electronic properties of surfaces, down to the nm scale, its combination with optical spectroscopy allows to overcome Abbé’s diffraction limit and record optical properties with subwavelength spatial resolution. The high spatial resolution of SPM makes it the method of choice for the study of nano- and nanostructured material.

4. Electron microscopy: students will get a basic understanding of electron microscopes and associated imaging and analytical techniques, in both, transmission and scanning modes (TEM and SEM). This course will cover the optics of the electron microscope and associated aberrations, image/diffraction formation mechnism, as well as possibilities and limitations of the different techniques for chemistry and materials science applications. Different imaging modes in TEM (high resolution, bright-/dark-field, weak-beam, and scanning modes), as well as electron diffraction techniques will be discussed, and examples for each imaging mode will be presented. A brief introduction to in-situ TEM and electron tomography will also be given.
In depth theory and data analysis of X-ray scattering forms part of CH-632, and, as in depth theory of electron diffraction and image formation - covered in the CIME course - will not be repeated here.

Keywords

Surfaces and solid state characterization, X-ray scattering (GIWAXS, GISAXS),
spectroscopy (XPS, AES, Raman), microscopy (AFM, TERS, SEM, TEM)

Learning Outcomes

By the end of the course, the student must be able to:

- Distinguish broad overview of state-of-the-art methods,choosing and designing method and experiment purposefully

Assessment methods

Written