

Subject:	Advanced tools in electron microscopy
Semester:	Spring
ECTS Credits:	2.5
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Department:	Electronics/ Physics UB Department of Electronics Facultad - Física UB

1. OBJECTIVES OF THE COURSE

1.1 General objectives of knowledge

- Know the fundamentals on electron microscopy and the related instrumentation.
- Be able to judge correctly the spatial and energy resolution limits, within the general context of characterization techniques.
- Know the different methods for sample preparation to be able to value their applicability in function of the specific problem and the possible risks of sample modification.
- Know the most recent perspectives on the application of electron microscopy tools for morphological and analytical characterization of nanostructures.
- Know the most prestigious international forums for spreading the advances in electron microscopy
- Know the nearer research centres as well as large international centres

1.2 Specific objectives

- Basic ability to use SEM and TEM microscopes
- Reach the Ability to differentiate the types of image formation between SEM and TEM. To know how to interpret the information and recognize possible misinterpretation sources.
- Know how to extract quantitative information based on the basic methods of image analysis and diffraction and on the related analytic techniques.
- Appreciate how suitable could be using microscopy tools to find a solution for a specific problem, taking into account human and economic effort according to the expected results.
- Define strategies for problem solving using electron microscopy and recognize how complementary it is with respect to other characterization techniques.
- Appreciate the complement of observations with quantification and simulation tools that are mandatory for a deep analysis of information.

1.3. Transversal Competences

- Self studying capability

- Ability of working as team
- Critical ability for judging the applicability and suitability of solutions.
- Interpretation of scientific texts on related topic.
- Redaction and communication of results
- Knowledge of the related scientific terminology in English.

2. CONTENTS

1. Instrumentation for Electron Microscopy:

Instrumental developments: Field emission filament, spherical aberration correctors, spectrometers and monochromators, energy filters. Advanced methods in sample preparation: biological samples, Focus Ion Beam (FIB).

2. Scanning Electron Microscopy (SEM): Cryomicroscopy. Cathodoluminescence (CL), Induced Currents (EBIC). Electron Back-Scatter Patterns (EBSP). Environmental scanning electron microscopy (ESEM), Advance observation methods. SEM tomography. Field Emission Gun Scanning Electron Microscope (FEG-SEM).

3. Transmission Electron Microscopy (TEM): Crystal diffraction. Indexing diffraction patterns. Double Diffraction. Kikuchi patterns. Formation and interpretation of images with diffraction contrast. Convergent-beam electron diffraction (CBED), Large-angle Convergent-beam Electron Diffraction (LACBED). Beam precision and electron crystallography. Nanodiffraction. Phase contrast. High-resolution transmission electron microscopy (HRTEM). Contrast transfer function. Sub-Angstrom resolution. Digital processing of high resolution images. Image simulation methods. Phase and amplitude reconstruction of emergent wavefunction..

4. Analytical Electron Microscopy (AEM): X-Ray Spectroscopy. Energy-dispersive detector (EDS), Wavelength-dispersive spectroscopy (WDS). X-Ray Energy Dispersive Spectroscopy (XEDS). Electron energy loss spectroscopy (EELS). Energy-loss Near-edge Structure (ELNES, EXELFS). Energy-filtered transmission electron microscopy (EFTEM). Applications on Nanostructured materials.

5. Advanced methods of analysis and observation: Electron tomography: Image formation and 3D reconstruction. Cryotomography. Applications on Material science and Life sciences. Scan-transmission electron microscopy. (STEM) and high-angle annular-dark-field scanning transmission electron microscopy (HAADF-Z contrast). Atomic resolution in analytical microscopy. Applications on Nanostructured materials. Other Microscopy techniques. Electron Holography. Lorentz microscopy.

3. METHODOLOGY

- Lecture sessions
- Independent study of the theory by the student.
- Lab session
- Resolution of exercises (Lectures/Lab)

- Reading of Scientific works
- Discussion of Scientific work
- Team work (groups activities)
- Test/ Final quiz.

Lectures and laboratory sessions.
Other independent activities.
Percent of non independent activities

42 Hours.

27 Hours.

60%

4. EVALUATION

Continuous evaluations along the course:

- Lectures: Attendance and participation during the course.
- Exercises and team work: Resolution and presentation.

Evaluation process can be complemented by final examination.

5. REFERENCES:

5.1 Basis References

- Physical Principles of Electron Microscopy : An Introduction to TEM, SEM, and AEM
Ray F. Egerton
Kluwer Academic-Plenum Publishers (2005) ISBN: 0-387-25800-0

- Transmission Electron Microscopy
M D.B. Williams, C.B. Carter
Plenum Press, New York, (1996). ISBN: 0-306-45247-2

- Scanning electron microscopy and X-Ray microanalysis
J.I. Glodstein, D. Newbury, D. Joy, C. Lyman, P. Echlin, E. Lifshin, L. Sawyer, and
J. Michael
3ªEd. Kluwer Academic-Plenum Publishers (2003) ISBN: 0-306-47292-9

5.2 Complementary References

- Electron Microscopy and Analysis
P. Goodhew, J. Humphreys, R. Beanland
3 Ed. Taylor & Francis (2001) ISBN: 7484-0968-8

- Electron energy-loss spectroscopy in the electron microscope
R.F. Egerton
2ª Edición. New York Plenum Press, (1996) ISBN: 0306452235

- Transmission Electron Microscopy and Diffractometry of Materials
Fultz, Brent, Howe, James M.
2nd ed. Springer (2002). ISBN: 3-540-43764-9

- Advanced Scanning electron microscopy and X-Ray micronanalysis
D.E. Newbury, D.C. Joy, P. Echlin, C.E. Fiori and J.I. Glodstein,
3ªEd. Kluwer Academic-Plenum Publishers (2003) ISBN: 0-306-42140-2