Microscopy Techniques

Academic Year: (2020 / 2021) **Review date: 16-07-2020**

Department assigned to the subject: Materials Science and Engineering and Chemical Engineering Department

Coordinating teacher: GONZALEZ BENITO, FRANCISCO JAVIER

Type: Compulsory ECTS Credits : 6.0

Year : 1 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

It is recommended to have been successful on the basics subjects associated to science or engineering degrees such as:

- General Chemistry.
- Physics.
- Mathematics.
- Chemical-Physics.
- Materials Science.

OBJECTIVES

COMPETENCES:

CB6, To have with understanding knowledge about materials characterization with the use of microscopy techniques giving the basis and the opportunity of being original in the development and application of ideas, mainly in a scientific and researching context.
CB7, Students must apply their acquired knowledge on the techniques of microscopy and their skills for solving morphological, topographical, textural problems on new environments or little known within wider contexts (multidisciplinary) related with the field of study.
CB8, students should be able of integrating different knowledge and affronting the complexity of formulating reasons from one information that, although being incomplete or limited, had thoughts about social and ethical responsibilities associated to their knowledge and decisions.
CB9, students should be able to communicate their conclusions so last reasons to specialized and non-specialized public in a clear way without ambiguities.
CB10, Students must possess the learning skills that enable them to continue studying in a way that will be mainly self-directed or autonomous.
CG1, students must understand the need and therefore, the usefulness of microscopy in the frame of Materials Science and Engineering within both and industrial and research contexts.
CG2, students must know the best methods in order to perform microscopy of materials to finally work properly in a laboratory of materials and optimize how to obtain results.
CG3, Students should develop teamwork skills in a research context.
CG6, Students should acquire the necessary skills to defend a results report about microscopy in a scientific and industrial environment.
CG7, Students should acquire creative and decision-making strategies to address problems related to observation of materials by microscopy in relation to their subsequent design, manufacturing and performance.
CE6, Students should know how to interpret, discuss and make conclusions from the experimental data obtained using different techniques of microscopy in the world of Materials Science and Engineering.
EC 9, Students must consolidate the specific research skills in the field of Materials Science and Engineering.
CE10, Students must acquire knowledge and skills about techniques of microscopy to solve specific problems associated with the working in a research laboratory in the field of designe, development and characterization of materials.

LEARNING OUTCOMES

Students should learned to:

1) Select a technique of microscopy suitable for obtaining specific information about a material.

2) Know the basics of the different techniques of microscopy:
- conventional Optical microscopy so as confocal.
- Scanning electron microscopy.
- Transmission electron microscopy-electron diffraction-STEM and contrast.
- Scanning tunneling microscopy.
- Atomic force microsocpy.
- Micro-spectroscopy.

3) Know the most appropriate methods for sample preparation when using the different techniques of microscopy considered.

4) Know the most appropriate methods for the analysis of the results obtained from the performance of the tests associated with the use of different microscopes.

5) Know the best way to present the results of microscopy.

6) Infer and get general conclusions from different kind of images of materials from the correct interpretation of the results.

DESCRIPTION OF CONTENTS: PROGRAMME

This course should provide an overview of the techniques of microscopy mostly used today to study materials, showing their potentialities and possible limitations. Therefore, the contents consider a brief description of the theoretical basis of the techniques, a description of the most characteristic tests, observations and how to prepare the samples. This point is always strengthened by the student's work in the laboratory. In addition, a proper training will be given so that students are able to interpret simple results independently obtained from different techniques and discuss their meaning in a context of researching.

Program:

Topic 01.- Introduction to techniques of microscopy

Topic 02.- Optical microscopy-Confocal microscopy.
* Basis, characteristic tests and observations.
* Examples of application.

Topic 03.- Scanning Electron Microscopy-SEM. basis, characteristics tests and observations ans examples of application.

Topic 04.- Transmission electron Microscopy-Electron diffraction-STEM and Z contrast
* Introduction to the electronic optics. Description of a transmission electron microscope.
* Image formation in a transmission electron microscope.
* Cinematic and dynamic theories of contrast. Defects contrast in crystalline structures.
* Introduction to the high resolution electron microscopy. Image calculations.
* Introduction to the scanning transmission microscopy, STEM.
* EELS and images of contrast in terms of atomic numbers.

Topic 05.- Scanning Tunneling Microscopy, STM: Basis, characteristics tests and observations, application examples.

Topic 06.- Atomic Force Microscopy, AFM: Basis, characteristics tests and observations, application examples.

Topic 07.- Micro-Spectroscopy: Basis, characteristics tests and observations, application examples.

LEARNING ACTIVITIES AND METHODOLOGY

TRAINING ACTIVITIES
AF1, Theoretical and practical lectures.
AF2, Lab.
AF3, Tutoring.
AF4, Work in group.
AF5, Individual work.
TEACHING METHODS.
MD1, Presentations or lectures in class with audiovisual media supports, in where the main concepts of the topics are exposed giving examples and solving exercises or case studies.

MD2, Critical reading by the students of recommended texts by Professor (scientific publications and books).

- Before accessing the laboratories, all students should watch some videos on safety in chemistry laboratories and, after that, they have to pass some virtual questionnaires (Aula Global) in order to demonstrate the contains of the videos are understood.
MD3, Resolution by the student (individually or in groups) of case studies, problems and exercises proposed by the teacher.
MD5, Obtaining experimental results in the laboratory. handling of equipments and research techniques under the guidance of the teacher.
MD6, Development of papers and reports individually or in groups.

ASSESSMENT SYSTEM

1) Participation in theory lectures and laboratory practices. (SE1) 0-5
2) Ability to demonstrate the acquisition of critical thinking skills about the contains of the subject. (SE1) 0-5

Weight (20% of the final mark).

3) To carry out works so as their corresponding presentations (exercises, individual or collective memories done throughout the course). (SE2) 20 to 30

Weight (10% of the final mark).

4) Participate in the laboratory practices, preparation, presentation and discussion of reports so as detailed questionnaires about the techniques used and experimental results. (SE3) 25 - 35

Weight (20% of the final mark).

4) Final exam of the course that have to be done individually, in writing or orally. (SE4) 40 - 50

Weight (50% of the final mark).

Note: in order to be considered the the above mentioned it is required to obtain in each of the parts at least a mark of 4 over 10 points.

% end-of-term-examination:	50
% of continuous assessment (assigments, laboratory, practicals…):	50

BASIC BIBLIOGRAPHY

- Bhushan, Bharat, Fuchs, Harald, Hosaka, Sumio Applied Scanning Probe Methods (Vols I and III), Springer, 2004

- Brady RF, Jr. Comprehensive Desk Reference of Polymer Characterization and Analysis, ACS, 2003

- J C H. Spence Experimental High Resolution Electron Microscopy, Oxford University Press, 1988

- J. Goldstein, D. E. Newbury, D.C. Joy, C.E. Lyman, P. Echlin, E. Lifshin, L.C. Sawyer, J.R. Michael Scanning Electron Microscopy and X-ray Microanalysis, Plenum Press, 2003
- J.I. Goldstein, D.E. Newbury, P. Echlin, D.C. Joy, C. Fiore, and El Lifshin Scanning electron microscopy and X-ray microanalysis, Plenum Press, 1992
- P.B. Hirsch Microscopy in Materials Science Series: Topics in Electron diffraction and Microscopy of Materials, IOP, 1999
- Reimer, Ludwig Transmission Electron Microscopy, Springer Verlag, 2008

- Reimer, Ludwig Transmission Electron Microscopy: Physics of Image Formation and Microanalysis, Springer, 1997

- Sergei N Magonov; Myung-Hwan Whangbo Surface analysis with STM and AFM : experimental and theoretical aspects of image analysis, VHC, 1996
- Williams, David B; Carter, C. Barry Transmission electron microscopy: a textbook for materials science, Willey, 2009

ADDITIONAL BIBLIOGRAPHY

- Egerton, Ray F. Electron energy-loss spectroscopy in the electron microscope, Plenum Press , 1996

- Lebeau, James M; Findlay, Scott D; Allen, Leslie J Quantitative atomic resolution scanning transmission electron microscopy, Physical Review Letters, 05/2008, Nº de Volumen 100, Núm. de revista 20. .
- Urban, Knut W Studying atomic structures by aberration-corrected transmission electron microscopy, Science, 07/2008, vol 321, Núm. de revista 5888.