UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# COURSE SYLLABUS

# Physical Chemistry of Solid State and Surfaces

**2223-1-F5302Q011**

## Aims

Relating fundamental concepts of the solid state and surface physical chemistry with applicative issues in the science and technology of semiconductors.

**Knowledge and understanding**

At the end of the course the student knows:

- The main characterization techniques for material and surface properties

- the main growth processes for semiconductor (bulk material and thin films)

- the role of defects on material properties with a focus on semiconductors

**Applying knowledge and understanding**

At the end of the course the student is able to:

- apply a method to understand and to predict the role of defects on material properties based on the chemical physics concept of solid solution

- analyse the results of surface and material characterization carried out with several characterization techniques such as SEM, EDX, XPS, SIMS

- know that any growth techniques could introduces defects which can modified the material properties and the device related performances

-recognise the role and the importance of the defects in material science

**Making judgements**

At the end of the course the student is able to:

- choose the best growth method and characterization techniques to be used according to the properties and functionality of the material he/she wants to have or to investigate

- avoid any contamination sources or to control them

**Communication skills**

The student will be able to describe and to explain orally with a suitable language the subjects of the class and to sustain a contradictory on the basis of judgment abilities developed autonomously on class topics

**Learning skills**

The student will be able to apply the acquired knowledge to contexts different from those presented during the course, and to understand the topics covered in the scientific literature concerning the defectivity in the materials, as well al the complex relationship among the growth processes and the material properties.

## Contents

Importance of defects on material properties, mainly in semiconductors. Elements of physical chemistry of surfaces. Adsorption phenomena: physisorption and chemisorption. Principal methods and techniques of Surface Characterization. Growth techniques of massive materials and thin film deposition procedures. Correlation of properties, defects and growth techniques.

## Detailed program

Defects in solids : Point and extended defects (dislocations, grain boundaries, antiphase domains, stacking fault) and their interactions. Elements of surface crystallography. Surface relaxation and reconstruction in vacuum. Surfaces of solids: estimate of surface energies and free energies. Adsorption phenomena: Langmuir adsorption isotherm, thermodynamics of adsorption. Physisorption: models, rates Chemisorption: molecular view, isotherms, kinetics. Principal methods and techniques of Surface Characterization ad defectuality characterization (SEM XPS, AUGER, SIMS, BET methods). Growth techniques of massive materials . General aspects of thin film deposition procedures and main thin film deposition techniques and relationships with material defectuality. Several case studies will be discussed for each topic

## Prerequisites

Main Physical Chemistry I, Matematics and Physic I

## Teaching form

Standard lessons supplemented by supporting multimedia tools functional to a better understanding of the practical aspects

## Textbook and teaching resource

- S. Eliot The Physics and Chemistry of solids Wiley
- J. D. Plummer , M.D. Deal, P.B. Griffin Silicon VLSI Technology Prentice Hall
- J. B. Hudson Surface science an introduction
- A. W. Adamson, A.P. Gast Physical Chemistry of Surfaces 6th ed. Wiley
- Hans-Jürgen Butt, Karlheinz Graf, Michael Kappl. Physics and Chemistry of Interfaces, 3rd Edition. ISBN: 978-3-527-41216-7 March 2013 495 Pages Wiley (try to use 3rd edition and not the 1st edition, since the book has been extensively revised and corrected).
- Geoffrey Barnes, Ian Gentle. Interfacial Science: An Introduction, 2nd Edition. ISBN: 9780199571185. Oxford.

All these books should be available in the UNIMIB library

## Semester

First year, Second (spring) semester

## Assessment method

The teacher assesses if and to what extent the student has reached the course objectives.
A formal knowledge-based evaluation of the general topics delivered. The examination is performed through an oral exam .
The students can do a mid term test: a class presentation of about 15 minutes on a topic selected by the students from a list of scientific articles that the teachers will give at about the end of March of each year. This presentation will count for 30% of the final grade

## Office hours

All days from Monday to Friday upon e-mail request

## Sustainable Development Goals

QUALITY EDUCATION | CLEAN WATER AND SANITATION | AFFORDABLE AND CLEAN ENERGY