UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Solid State and Surface Physical Chemistry

2425-2-F5401Q037

Aims

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

Knowledge and understanding
At the end of the course the student knows:

- the kind of defects and their role on material properties with a focus on semiconductors
- the main characterization techniques for identification of defects and surface properties
- the relationship among the main growth processes for semiconductor (bulk material and thin films) and the defectivity of the materials

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
- understand how any growth techniques could introduce defects which can modify the material properties and the device related performances
- recognise the role and the importance of the defects in Materials 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 functionalities of the material he/she wants to achieve or investigate
- identify any contamination source or introduction of defects during the growth or fabrication of a device and

the strategies to avoid or control it

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
At the end of the course, the student will be able to describe and to explain orally, with the appropriate language, the topics of the class and to sustain a contradictory on the basis of judgment abilities developed autonomously on scientific publications inherent to the class topics (see assessment modality)

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 (Cz technique) 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 faults) and their interactions.

Free-surfaces: elements of surface crystallography. Surface relaxation and reconstruction in vacuum. Estimate of surface energies.

Adsorption phenomena: physisorption and chemisorption, models, thermodynamics and kinetics of adsorption, adsorption isotherms (Langmuir and BET isotherms)

Principal methods and techniques of surface characterization and defectuality characterization (XPS, DLTS, SIMS, BET methods).

Growth techniques of bulk materials (single- and poly-cristalline). Relationship between growth conditions and defectuality.

Thin film deposition techniques (evaporation, sputtering, Chemical Vapour Deposition, Molecular Beam Epitaxy and their impact on material defectuality. Epitaxy and misfit dislocations. Criterions for selecting the appropriate growth method and process optimization.

Several case studies will be discussed for each topic. Particular space will be given to silicon technology

Prerequisites

Bachelor courses of Physical Chemistry, Matematics and General Physics

Teaching form

16 two-hour lectures, in person , Delivered Didactics (lessons supplemented by supporting multimedia tools functional to a better understanding of the practical aspects)
5 two-hour practical classes, in person : Delivered Didactics
3 two-hour seminar activities, in person : Interactive Teaching

Upon reasoned request of the entire class (for example partial overlap of timetables with other courses of choice) or in the case of a working student, recordings of the lessons may be made available

Textbook and teaching resource

The following textbooks, available from the UNIMIB library, are suggested for more extensive treatment of the class topics:
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.
U.W. Pohl, Epitaxy of semiconductors, Springer

Semester

First year, Second (spring) semester

Assessment method

The exam consists of an oral interview about the topics of the lessons and a class presentation . The teacher assesses if and to what extent the student has reached the course objectives by a formal knowledge-based evaluation of the student understanding and judgement on the general topics and applications. The grade is given on the scale of thirtieths, including the possible cum laude attribution, and is based on the degree of completeness and quality of the student replies.
The students must do at the end of the course 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 | AFFORDABLE AND CLEAN ENERGY