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EUROPEAN UNIVERSITY FOR CUSTOMISED EDUCATION

STUDY GUIDE

Physical Chemistry of Materials

Organised by

Università di Catania

1. IDENTIFYING DATA.	
· **Course Name.**	*Physical Chemistry of Materials*
· **Coordinating University.**	*Università di Catania*
· **Partner Universities Involved.**	---
· **Course Field(s).**	*Physics, Chemistry, Materials Science*
· **Related Study Programme.**	*International Master in Chemicals Sciences, LM54*
· **ISCED Code.**	*0531 Chemistry*
· **SDG.**	*SDG Goal 4: Inclusive and equitable quality education* *SDG Goal 7: Affordable and clean energy* *SDG Goal 9: Industry, innovation and infrastructure*
· **Study Level.**	*The course is part of the International Master in Chemical Sciences (LM54) program*

· **Number of ECTS credits allocated.**	*6*
· **Mode of Delivery.**	*Online (intended for EUNICE)*
· **Language of Instruction.**	*English*
· **Course Dates.**	*from 01/10/2024 to 18/01/2025*
· **Schedule of the course.**	*First semester*
· **Key Words.**	*Crystalline structure, Thermodynamics of crystal growth, Defects in crystals, Vibrations in crystalline solids, Electronic band structure and properties, Semiconductors and devices, Optical properties of materials, Nanoscience and nanotechnology*
· **Catchy Phrase.**	*Materials science: The science of discovery, the art of invention*

· **Prerequisites and co-requisites.**	*Elements of Calculus – Thermodynamics and classical mechanics – Principles of quantum mechanics – General Chemistry.*
· **Number of EUNICE students that can attend the Course.**	*unrestricted number*
· **Course inscription procedure(s).**	----

2. CONTACT DETAILS.

· **Department.**	*Dipartimento di Scienze Chimiche, Univ. di Catania*
· **Name of Lecturer.**	*Giuseppe Compagnini*
· **E-mail.**	*Giuseppe.compagnini@unict.it*
· **Other Lecturers.**	-----

3. COURSE CONTENT.

- **Crystalline structure**

Lattices and unit cells. Bravais lattices. Crystalline planes and directions. Miller indices. Packing energy and structures. Covalent and ionic crystals. Molecular crystals. Defects in crystalline structures. Point and extended defects. Defects thermodynamics.

- **Crystalline structure: determination and analysis**

Interference and diffraction: general concepts. Diffraction od crystalline phases. Laue and Bragg laws. Fourier transforms and reciprocal lattices. single-crystals, poly-crystals and nano-crystals. Diffraction in the amorphous phases.

- **The electronic system in the solid state**

Charge carriers and transport under electric and magnetic fields. Free electrons and bound electrons. Bloch theorem and band structure. Dispersion relations for electrons. Density of states. The Fermi- Dirac distribution. Metals, semiconductors, insulators. Applications to nanomaterials.

- Semiconductors and applications

Charge carriers in semiconductors. Electrons, holes and their motion. Carrier concentration and the law of mass action. Direct and indirect gap semiconductors. Doping. Some few semiconductor devices: pn-junction and the diode, transistors. Applications to photonics and electronics.

- **Lattice vibrations and thermal properties**

Lattice and molecular vibrations: a comparison. Vibrational dispersion relations. Acoustic and optical branches. Phonons. Vibrational density of states and Debye frequency. Vibrational spectroscopy in solids. Specific heat in solids. The Dulong Petit law. Low temperatures.

- **Dielectric and optical properties**

Polarizability and dielectric function. Macroscopic response to an electromagnetic radiation. Absorption, reflection at a boundary, elastic and anelastic diffusion. The Lorentz model. Complex refractive index and dielectric function. Free electrons and plasmons. Applications to energetics, catalysis and the environment. The use of lasers in chemistry and materials science.

4. LEARNING OUTCOMES.

The course aims to provide students with a sufficiently broad picture of matrials science and their applications to technology. After wide introduction on the basics of solid state physics and chemistry, experimental techniques and theoretical approaches in the field are presented. The

course also aims to enhance:

Knowledge and understanding.

Critical understanding of the most advanced experimental procedures and techniques related to the physics and chemsitry of materials needed for applications in today technology.

Applying knowledge and understanding

Ability to identify the essential elements of a phenomenon, also in terms of order of magnitude and level of approximation necessary, for applications in materials science.

Ability to use analogy as a tool to apply known solutions to new problems (problem solving).

Ability to plan and apply experimental and theoretical procedures to new measurements, or to improve existing results.

Making judgements

Ability to convey own interpretations of materials science phenomena, when discussing within a research team.

Communication skills.

Ability to discuss about advanced materials science concepts, both in Italian and in English.

Learning skills.

Ability to acquire adequate tools for the continuous update of one's knowledge. Ability to exploit databases and bibliographical and scientific resources to extract information and suggestions to better frame and develop one's study and research activity. Ability to acquire, through individual study, knowledge in new scientific fields.

5. OBJECTIVES.

The course aims at providing the following objectives:
- correlate material characteristics to chemical and physical properties;
- design molecular and solid state structures and apply new materials, including nanomaterials, for advanced applications in various fields;
- study of devices for industrial applications in microelectronics, optoelectronics, bioelectronics, photonics, nanomaterials, manufacturing techniques, and characterization methods;

6. COURSE ORGANISATION.

UNITS

1.	*Crystalline structures*
2.	*Crystalline structure: determination and analysis*
3.	*The electronic system in the solid state*
4.	*Semiconductors and applications*

5.	*Lattice vibrations and thermal properties*
6.	*Dielectric and optical properties*

LEARNING RESOURCES AND TOOLS.

Lectures will be delivered by using slides prepared by the teacher.

PLANNED LEARNING ACTIVITIES AND TEACHING METHODS.

Learning activities are in the form of lectures on the different topics. Seminars could be also delivered.

7. ASSESSMENT METHODS, CRITERIA AND PERIOD.

At the end of the course, an oral exam is foreseen.

OBSERVATIONS.

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8. BIBLIOGRAPHY AND TEACHING MATERIALS.

S.Elliott: The physics and chemistry of solids
C.Kittel: Introduction to solid state physics