



# UNIVERSITÀ DEGLI STUDI DI PALERMO

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| DEPARTMENT                   | Ingegneria                                                                                                                     |
| ACADEMIC YEAR                | 2019/2020                                                                                                                      |
| MASTER'S DEGREE (MSC)        | CHEMICAL ENGINEERING                                                                                                           |
| SUBJECT                      | APPLIED PHYSICAL CHEMISTRY                                                                                                     |
| TYPE OF EDUCATIONAL ACTIVITY | C                                                                                                                              |
| AMBIT                        | 20911-Attività formative affini o integrative                                                                                  |
| CODE                         | 17559                                                                                                                          |
| SCIENTIFIC SECTOR(S)         | ING-IND/23                                                                                                                     |
| HEAD PROFESSOR(S)            | INGUANTA ROSALINDA Professore Associato Univ. di PALERMO                                                                       |
| OTHER PROFESSOR(S)           |                                                                                                                                |
| CREDITS                      | 6                                                                                                                              |
| INDIVIDUAL STUDY (Hrs)       | 96                                                                                                                             |
| COURSE ACTIVITY (Hrs)        | 54                                                                                                                             |
| PROPAEDEUTICAL SUBJECTS      |                                                                                                                                |
| MUTUALIZATION                |                                                                                                                                |
| YEAR                         | 1                                                                                                                              |
| TERM (SEMESTER)              | 2° semester                                                                                                                    |
| ATTENDANCE                   | Not mandatory                                                                                                                  |
| EVALUATION                   | Out of 30                                                                                                                      |
| TEACHER OFFICE HOURS         | <b>INGUANTA ROSALINDA</b><br>Tuesday 15:00 18:00 Studio Secondo Piano ed. 6<br>Thursday 15:00 18:00 Studio Secondo Piano ed. 6 |

**DOCENTE:** Prof.ssa ROSALINDA INGUANTA

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| <b>PREREQUISITES</b>          | Fundamentals of Chemistry and Applied Chemistry<br>Fundamentals of Thermodynamics and Transport Phenomena<br>Fundamentals of Electrotechnics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>LEARNING OUTCOMES</b>      | <p>Knowledge and understanding skills<br/>Knowledge of the structure of solid materials, and of the chemical-physical properties of metals, starting from the crystalline structure and the electron energy. Knowledge of the properties of semiconductors and their behavior in solid state junctions.<br/>The achievement of this objective is assessed during the oral test.</p> <p>Ability to apply knowledge and understanding<br/>Selection of material type for different applications. Ability to intervene in the manufacturing processes of devices used for electronics and for the conversion of electric light into electricity.<br/>The achievement of this objective is assessed during the oral test.</p> <p>Judgment autonomy<br/>To be able to establish the appropriate procedures for the choice and tailoring of metallic, insulating or semiconductor materials for technological applications.<br/>The achievement of this objective is assessed during the oral test.</p> <p>Communication skills<br/>Ability to communicate with other technical figures and with experts in the field of electronics manufacturing.<br/>The achievement of this objective is assessed during the oral test.</p> <p>Learning ability<br/>Update skills with the consultation of the scientific publications of the metallurgical and physical chemistry sectors.<br/>The achievement of this objective is assessed during the oral test.</p> |
| <b>ASSESSMENT METHODS</b>     | <p>The final examination consists in a oral test. The questions will relate to the contents covered during the course and listed at the end of this document. The final assessment, properly graded, will be made on the basis of the following conditions:</p> <p>a) sufficient knowledge of subjects addressed in the course; sufficient degree of awareness and autonomy in the application of theories to solve chemical problems (rating 18-21);</p> <p>b) Good knowledge of subjects addressed in the course; fair degree of awareness and autonomy in the application of theories to solve chemical problems (rating 22-25);</p> <p>c) Good knowledge of subjects addressed in the course; good degree of awareness and autonomy in the application of theories to solve chemical problems (rating 26-28);</p> <p>d) Excellent knowledge of subjects addressed in the course; excellent level of awareness and autonomy in the application of theories to solve chemical problems (rating 29-30L).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>EDUCATIONAL OBJECTIVES</b> | Provide a basic understanding of the structure, the chemical-physical characteristics of metallic, insulating and semiconductor materials, as well as on the operation and manufacturing processes of electronic and photovoltaic devices.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>TEACHING METHODS</b>       | The course takes place in in the second half of the first year, and consists of lectures and laboratory exercises.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>SUGGESTED BIBLIOGRAPHY</b> | <p>- P. Wilkes, Solid State Theory in Metallurgy, Cambridge University Press (1973).</p> <p>- R. H. Bube, Electrons in Solids, 3a Ed., Academic Press, New York (1992).</p> <p>- W.G.Moffatt, G.W.Pearsall, J Wulff, Struttura e proprieta' dei materiali, C.E.A., Milano (1975).</p> <p>- C.S. Solanki, Solar Photovoltaics, 2a Ed., PHI Learning Private Ltd. (2011)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

## SYLLABUS

| Hrs | Frontal teaching                                                                                                                               |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------|
| 2   | Presentation of the course. Structure of solids: Atoms, Electrons, Conductivity. Work Function of a Metal.                                     |
| 4   | Quantum Mechanics: Discoveries and Fundamental Principles. Electrons as waves                                                                  |
| 2   | Schroedinger's equation for non-stationary and stationary states. Auto-functions and Auto-values                                               |
| 2   | The electron in an infinite and finite potential hole. Degeneration of energy levels. Tunneling effect.                                        |
| 3   | The theory of free electron in metals. Space k, state density function, occupation function.                                                   |
| 5   | The properties of metals. Conductivity: scattering phenomena. Superconductivity. Electronic Contribution to Specific heat. Emission phenomena. |
| 4   | Defects in solids: point defects. Dislocations, plastic deformation. Surface defects. Polycrystalline Solids; Grain edges.                     |

## SYLLABUS

| Hrs | Frontal teaching                                                                                                                                                       |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3   | Band theory in the Solids: Kronig-Penney's model. Brillouin areas. Metals, insulators, semiconductors. Driving in the Bands.                                           |
| 5   | Semiconductor Physics. Intrinsic and extrinsic semiconductors. Doping. Fermi Level and Density carriers. Optical Transitions.                                          |
| 4   | Junctions M-M, MIS, M-SC. Study of the Schottky Barriers. SC-electrolyte junction. Amorphous semiconductors. P-n junction.                                             |
| 2   | Production of EGS and silicon micro and monocrystals. Production stages of p-n micro-junctions. Microlithography, etching, doping. Micro-transistors, VLSI technology. |
| 3   | Photovoltaic solar cells: description and principles of operation                                                                                                      |
| 5   | Description of the various types of photovoltaic cells. Silicon technology and thin film technology                                                                    |
| 2   | New technologies: organic semiconductor cells, nano-structured cells, dye cells, perovskite cells                                                                      |
| 3   | Multi-junctions cells and solar concentrators                                                                                                                          |
| Hrs | Practice                                                                                                                                                               |
| 1   | Laboratory exercise: operating principles of a field emission microscope                                                                                               |
| 1   | Laboratory exercise: principles of operation of an XRD and identification of crystalline structures                                                                    |
| 3   | Laboratory Exercise: Working tests on thin film solar cells                                                                                                            |