MATERIALS ENGINEERING AND NANOTECHNOLOGY (LM56)

(Lecce - Università degli Studi)

Teaching ELECTROCHEMICAL TECHNOLOGIES

GenCod A003093

Owner professor CLAUDIO MELE

Teaching in italian ELECTROCHEMICAL TECHNOLOGIES

Teaching ELECTROCHEMICAL TECHNOLOGIES

SSD code ING-IND/23

Reference course MATERIALS ENGINEERING AND

Course type Laurea Magistrale

Credits 9.0

Teaching hours Front activity hours: 81.0

For enrolled in 2019/2020

Taught in 2019/2020

Course year 1

Language ENGLISH

Curriculum PERCORSO COMUNE

Location Lecce

Semester Second Semester

Exam type Oral

Assessment Final grade

Course timetable
https://easyroom.unisalento.it/Orario

BRIEF COURSE DESCRIPTION

Contents

The course is focused on the fundamentals of electrochemistry and its technological applications, including corrosion, industrial electrochemical processes and electrochemical energy conversion and storage systems.

REQUIREMENTS

Prerequisite

Basic knowledge of calculus, physics and chemistry.

COURSE AIMS

Learning outcomes

Knowledge and understanding

The aim of the course is to provide students with the fundamentals of electrochemistry and its technological applications, including corrosion, industrial electrochemical processes and electrochemical energy conversion and storage systems.

Applying knowledge and understanding

After the course, the students should:

- have acquired the skills necessary to address the broad theme of electrochemical technologies, discussing in particular the most important variables, both from a thermodynamic and kinetic point of view;
- have understood the mechanisms of charge transfer and be able to describe the structure of the electrochemical interface;
- have acquired the basic tools for understanding the corrosion of metallic materials in the different environments in which they can be used;
- be able to discuss the electrochemical processes applied to industrial production;
- have understood the electrochemical devices for electrochemical energy conversion and storage systems.

Making judgements

The course provides the ability to critically address electrochemical, corrosion and energy conversion and storage problems.

Communication

The course promotes the ability of the students to expose to experts their acquired scientific knowledge in precise and formal terms and to non-specialists by using elementary concepts.

Learning skills

Students are encouraged to acquire the critical skills to deal with typical theoretical and practical electrochemical problems. They should be able to expose their acquired knowledge summarizing notions from books and slides.

TEACHING METHODOLOGY

Teaching Methods

The course consists of frontal lessons using slides made available to students and classroom exercises. The frontal lessons are aimed at improving students' knowledge through the presentation of theories, models and methods. Numerical and practical exercises are aimed at a better understanding of the theory.

ASSESSMENT TYPE

Examination

In the final exam (oral) the topics presented during the lectures will be addressed; the results obtained during the laboratory exercises will be discussed with the possibility to solve simple numerical exercises.

OTHER USEFUL INFORMATION

Office hours

Wednesday, 11.30-13.30;
other days, by appointment fixed by e-mail or at the end of the class.

FULL SYLLABUS

Course Content

1. Fundamentals of electrochemistry (6 hours)

Fundamentals of electrochemistry. Ions, electrolytes and quantisation of the electrical charge. The nature of electrode reactions. Transition from electronic to ionic conductivity in an electrochemical cell.

2. The electrode-solution interface (6 hours)

The electrode-solution interface. The electrical double layer. Electrolysis cells and Galvanic cells.

3. Electrochemical thermodynamics (9 hours)

Electrochemical thermodynamics. Complex thermodynamic systems. Equilibrium in thermodynamic Systems. Thermodinamical potentials. Chemical work. Chemical potential. Unary and multicomponent, homogeneous and heterogeneous systems. Nonreacting and reacting systems. Conditions for equilibrium. Thermodinamics of surfaces. Surface tension. The equilibrium shape of crystals. Adsorption at surfaces. Electrode potential and thermodynamics. Electrochemical potential. Electrocapillary equation.

4. Electrochemical kinetics (9 hours)

Electrochemical kinetics. Kinetics aspects of the corrosion. Overpotential. Activation, concentration and ohmic overpotentials. Butler-Volmer equation. Tafel equation. Limit current. Mass transfer and current distribution in electrochemical systems. Transport in electrolytic solutions. Primary and secondary current distribution.

5. Corrosion (9 hours)

Fundamentals aspects of corrosion of metallic materials. Uniform and localized corrosion. Faraday laws. Electrochemical mechanism of the corrosion. Anodic and cathodic reactions. Thermodynamics aspects of the corrosion. Nernst equation. Stability diagram for water. Applications of the Nernst Equation. Cell potentials and concentrations. Concentration cells. Pourbaix Diagrams. Corrosion, passivation and immunity regions. Passivation and passivity of metals. Active-passive metals. Principles of galvanic corrosion. Evans Diagrams. Corrosion prevention and protection methods.

6. Industrial electrochemical processes. (6 hours)

Electrodeposition, electroforming, electrorefining.

7. Electrochemical energy conversion and storage systems (6 hours)

Electrochemical energy conversion and storage systems. Primary and secondary batteries. Electrochemical reactions. Storage capacity. Energy density. Power density. Fuel cells. Electrochemical supercapacitors.

8. Techniques for the study of electrochemical interfaces (6 hours)

Electrochemical methods for the study of the electrode/electrolyte interface. Quasi-stationary methods. Two electrode and three electrode systems.

Numerical exercises

9. Corrosion (6 hours)

10. Electrochemical energy conversion and storage systems (6 hours)

Laboratory exercises

11. Electrochemical techniques (6 hours)

Electrochemical techniques. The potentiostat. Current-potential curves. Quasi-stationary methods. Cyclic voltammetry.

12. Spectroelectrochemical techniques (6 hours)

Spectroelectrochemical techniques. Infrared spectroscopy. Raman spectroscopy. Spectroellipsometry

REFERENCE TEXT BOOKS

Textbooks

[1] C.H. Hamann, A. Hamnett, V. Vielstich - Electrochemistry

[2] V. S. Bagotsky - Fundamentals of Electrochemistry

[3] R.T. Dehoff - Thermodynamics in Materials Science

[4] P. Pedeferri - Corrosione e protezione dei materiali metallici