MATERIALS ENGINEERING AND NANOTECHNOLOGY (LM56)

(Lecce - Università degli Studi)

Teaching BATTERIES AND FUEL CELLS

GenCod A005650

Owner professor PATRIZIA BOCCHETTA

Reference professors for teaching PATRIZIA BOCCHETTA, PAOLA LEO

Teaching in italian BATTERIES AND FUEL CELLS

Teaching BATTERIES AND FUEL CELLS

SSD code ING-IND/21

Reference course MATERIALS ENGINEERING AND

Course type Laurea Magistrale

Credits 9.0

Teaching hours Ore-Attivita-frontale: 81.0

For enrolled in 2020/2021

Taught in 2020/2021

Course year 1

Language INGLESE

Curriculum PERCORSO COMUNE

Location Lecce

Semester Primo-Semestre

Exam type Orale

Assessment Voto-Finale

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

BRIEF COURSE DESCRIPTION	The course aims to provide the students with fundamental knowledge and understanding in electrochemical energy conversion and storage. Electrochemical, technological and metallurgical aspects of batteries and fuel cells devices are emphasized through theoretical lessons and numerical as well as experimental practice.
REQUIREMENTS	Basic knowledge of physics and chemistry.

COURSE AIMS

Knowledge and understanding

The course provides the basic concepts of electrochemical processes applied to energy conversion and storage systems

by focusing the attention on the performance, application, material science, and corrosion aspects of the batteries and fuel cell devices.

Applying knowledge and understanding

After the course, the student will acquire a basic knowledge of the principal topics of electrochemical charge storage and energy conversion. The student will learn theoretical and technological aspects of batteries, fuel cells and supercapacitor devices. The student will also understand metallurgical and environmental aspects of batteries and fuel cells finalized to prevent degradation and promote eco-friendly systems and recycle processes of wastes.

Making judgments

Students will acquire the ability to critically discuss the principal problems related to batteries and fuel cell and to propose solution to material choices, corrosion phenomena and stability issues by using basic electrochemical and metallurgical notions.

Communication

The students will be able to communicate the scientific knowledge and methodological tools acquired in the course with a varied and composite audience in a clear and technical way. The student will sustain conversations on electrochemical energy conversion themes by evidencing vantages and disadvantages if compared with other energy conversion methods. The ability to use a technical language will be improved during the laboratory practice, where the students will be called to propose solutions to the investigated systems.

Learning skills

The student will acquire basic concepts of applied electrochemistry that will guide him/her to a critical assessment of the positive and negative aspects of a novel energy storage or conversion system and to the project of possible solutions. These skills will be enhanced thanks to a long and focused laboratory practice.

TEACHING METHODOLOGY

The course consists of frontal lessons, numerical and experimental exercises. Class contents will be given on the board or presented with the aid of Power Point Slides. Interactions with students will be stimulated during lessons in order to keep high the attention and comprehension of the contents.

ASSESSMENT TYPE

Exams will be composed of an oral discussion of the theoretical part of the course (6 credits) and a written report on the experimental activity (3 credits).

The oral discussion will relate on four topics:

1. Energetic aspects of energy storage and conversion devices;
2. Kinetic aspects of energy storage and conversion devices;
3. Dicussion of a battery/fuel cell system;
4. Enviromental and corrosion aspects of a battery/fuel cell system

With the aim to verify to what extent the student has acquired the aptitude to manage electrochemical theoretical aspect of batteries/fuel cells systems and to apply them to the design and problem solving activities characteristic of these devices.

The written report on the experimental activity will be evaluated by taking into account the level of the scientific discussion, the correctness of the technical language and the completeness/precision of the overall document.

FULL SYLLABUS

Theoretical lessons (6 credits)

Introduction to the course.

Introduction to electrochemistry. Differences between chemical and electrochemical reactions.

Energetic aspects of galvanic systems.

Notes on electrolytic solutions. Transport phenomena in solution. Migration, diffusion, convection.

Fundamental aspects of electrochemical kinetics in batteries: charge-transfer, diffusion and ohmic control. Charge-discharge curves.

Faradaic and non Faradaic processes. Electrode/Electrolyte double layer. Helmolz e Gouy-Chapman Models. Electrochemical Impedance Spectroscopy: principles and applications to the characterization of energy storage and conversion devices. Bode and Nyquist diagrams. Circuital models.

Electrochemical energy storage and conversion: introduction and electrochemical fundamental aspects.

Present state of the art of energy storage and conversion devices for application in mobile (consumer electronics

and biomedical devices), transport (hybrid and electric vehicles) and stationary (wind and photovoltaic systems).

Ragone plot.

Primary Batteries: conventional cells (Leclanche, manganese oxide/Zn, silver oxide/Zn, Zn/air), lithium batteries, reserve batteries, thermal batteries, sea batteries.

Secondary Batteries: Pb-acid, nickel - cadmium, silver- zinc, Zn-air.

alluminium - air, nickel - metal hydride, lithium. ZEBRA battery.

Processes and materials for hydrogen production and storage.

Fuel Cells: operating principle, general characteristic and classification. Advantages and disadvantages. Triple contact electrodes. Thermodynamic and kinetic aspects. Polarization curves. Membrane Electrodes Assembly.

Polymeric Electrolyte Fuel Cells (PEFC). Materials and operation of catalyzed electrodes and polymeric electrolytes. Perfluorosulfonic membranes (Nafion) and proton transport mechanisms. Water management.

Alkaline Fuel Cells. Phosphoric Acid Fuel Cells. Direct methanol fuel cells. Molten carbonate fuel cells. Solid oxide Fuel Cells.

Electrochemical capacitors and supercapacitors. Hybrid supercapacitors. Electrolytic supercapacitors.

Corrosion in batteries and fuel cells: fundamentals of electrochemical corrosion and metallurgical aspects in batteries and fuel cells.

Environmental impact of batteries and fuel cells.

Numerical exercises on energetics and kinetics of galvanic systems, energy conversion and storage, corrosion phenomena applied to batteries and fuel cells.

Laboratory Practice (3 credits)

Fabrication and electrochemical study of conventional batteries (such as Daniell cell, Zn-air) and fuel cells (PEMFC). focusing the attention on the Nernst equation and equilibrium potential measurements, battery technology and components, half-cell reactions, charging/discharging tests, and performance analysis.

Metallurgical aspect of corrosion processes.

Electrochemical corrosion of materials typically used in battery and fuel cell systems.

Microstructure analysis of samples affected by electrochemical corrosion.

Electrochemical corrosion of samples characterized by the same composition and different microstructures:

microstructural analysis and mechanical performances.

REFERENCE TEXT BOOKS	Electrochemical Methods - Fundamentals and Applications, A. J. Bard, L. R. Faulkner, Wiley (II edition), 2001 Modern Electrochemistry 2B, 2nd edition J. O'M. Bockris e A.K.N. Reddy Kluwer Academic/Plenum Publishers NY (2000) Pietro Pedeferri, Corrosione e protezione dei materiali metallici. Vol. I e Vol. II, polipress, 2007, Milano Italia Papers and reviews provided during the course.