UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2016/2017
BACHELOR'S DEGREE (BSC)	BIOMEDICAL ENGINEERING
SUBJECT	CORROSION IN BIOLOGICAL ENVIRONMENTS
TYPE OF EDUCATIONAL ACTIVITY	D
AMBIT	10437-A scelta dello studente
CODE	18452
SCIENTIFIC SECTOR(S)	ING-IND/23
HEAD PROFESSOR(S)	SANTAMARIA MONICA Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	3
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**SANTAMARIA MONICA** Monday 13:00 14:00 Studio personale Edificio 6 secondo piano previa conferma per e-mail Wednesday 12:30 14:00 Studio personale Edificio 6 secondo piano previa conferma per e-mail Friday 12:30 14:00 Studio personale Edificio 6 secondo piano previa conferma per e-mail

DOCENTE: Prof.ssa MONICA SANTAMARIA

PREREQUISITES	General and Inorganic Chemistry, basic electricity with an emphasis on Ohm's Laws.
LEARNING OUTCOMES	Knowledge and understanding At the end of the course student is expected to have a deep understanding of the mechanism of corrosion processes and on their nature as a function of the environmental physico-chemical conditions with special emphasis on the corrosion in biological environment. Student will be aware on the synergistic effect of stress and corrosion in materials degradation and failure. He/ she is expected to know the corrosion protection methods and strategies and to isolate the critical issues responsible of material degradation and the consequent effect on human body. Applying knowledge and understanding Student is expected to know corrosion mechanism and morphology of the metallic material indifferent environments. Thanks to this fundamental knowledge he/she will be able to understand causes of the corrosion processes involving biomaterials, being able to select the most appropriate surface treatment to enhance corrosion resistance of biometallic material according to the environmental conditions. Making judments Staring from knowledge of the theoretical aspects of the corrosion processes as well as from the laboratory experiences the student is expected to be able to match the right metallic biomaterial with the environment where the latter is supposed to work, and he/she will regulate the material composition and its surface finishing, in order to ensure safe and correct functioning during operating conditions. Communication Student is expected to be able to work autonomously and collaborate with other team members involved in the same project (biomaterial selection and/or maintenance). Learning skills Following a deep understanding of the theoretical aspects and a after laboratory experience, student is expected to be able to seek advice from technical regulations, technical manuals, scientific literature updating frequently his/her knowledge.
ASSESSMENT METHODS	Oral exam and discussion on a case study selected by the student. To earn the minimum score, student must know the fundamental aspects of the course. Higher score will be attributed according to the student ability in applying knowledge and skills learned in this course to practical and technical problems, and according to what extent students are aware of the steps they go through in solving problems and how well they can explain their problem-solving steps.
EDUCATIONAL OBJECTIVES	The aim of the course is to provide basic concepts of corrosion processes and the tools for a correct selection of the biomaterials, of the protection and prevention methods to control and limit the damages and failure.
TEACHING METHODS	Frontal lectures, Laboratory and Demonstration Sessions, Laboratory Practice Sessions
SUGGESTED BIBLIOGRAPHY	Pietro Pedeferri, Corrosione e protezione dei materiali metallici. Vol. I e Vol. II, polipress, 2007, Milano Italia. Advances in Metallic Biomaterials, M. Niinomi, T. Narushima, M. Nakai Editors, Springer-Verlag Berlin Heidelberg 2015 Lectures notes and powerpoint presentations.

SYLLABUS

Hrs	Frontal teaching
2	Introduction. General aspects of corrosion processes. Mechanical and physico-chemical properties of materials. Metallic biomaterials. Direct and indirect corrosion damages.
6	Wet and dry corrosion. Electrochemical mechanism of corrosion. Corrosion reactions: anodic and cathodic half cell reactions. Farday's law. Thermodynamics of corrosion. Standard potential, Nerst Equation and Pourbaix. diagrams.
6	Kinetic of corrosion. Cathodic and anodic overvoltage.Charge transfer and mass transfer control. Passivation conditions. Evan's diagrams. Influence of metal on corrosion processes.
5	Corrosion attack morphology: generalized corrosion, galvanic coupling, pitting corrosion, crevice corrosion, selective dissolution, intergranular corrosion, turbulence corrosion, erosion corrosion, impingement corrosion, stress corrosion cracking, fatigue corrosion, hydrogen embrittlement, microbial corrosion.

SYLLABUS

Hrs	Frontal teaching
6	Corrosion of metallic biomaterials in cell colture. Effect of Components and Physiological Environment on Corrosion of Metallic Biomaterials Corrosion of Degradable and Hybrid Metallic Biomaterials Corrosion of Nanostructure Metallic Implants. Corrosion of Bio-absorbable Metallic Materials. Corrosion of implant materials in the body. Mechanical working conditions in the human body.
3	Protection of metallic biomaterials. Surface finishing: tumbling, electropolishing, passivation and anodizing. Surface oxide film on metallic materials in biological environment.
2	Electrochemical Measurements in Cell Culture Environments. Electrochemical Impedance measurements. Standard Tests for Evaluation of Corrosion of Metallic Biomaterials in Physical Body Fluid.
5	Alloying electrochemistry and corrosion resistance of metallic biomaterials: stainless steel, Cobalt-based alloys, Titanium alloys, NiTi shape-memory alloys, Magnesium alloys, Tantalum, Zirconium alloys
1	Effect of corrosion-failure of implants (Cardiovascular Implants, Corrosion of Dental Implants, Corrosion of Orthopedic Implants).
1	Monitoring, Control and Prevention Practices of Biomaterials Corrosion
2	Corrosion tests: corrosion rate estimate, coating efficiency corrosion prevention and/or in corrosion mitigation, interpretation of the experimental results, etc.).
1	Design and selection of material: data base consulting, smart systems and regulations. Economic evaluation and reliability assessment.

Hrs	Practice
2	Pourbaix diagrams from thermodynamics data and their use in corrosion studies.
2	Kinetic parametrs estimated from polarization curves. Evans diagram construction.
2	Kinetic of redox K4Fe(CN)6 - K3Fe(CN)6 redox reaction. H2 evolution on Pb and Pt. O2 reduction.
2	Experimental determination of corrosion potential and corrosion rate (d.c. and a.c. methods to estimate polarization resistance)
2	Corrosion products identification by X-ray diffraction and Raman Spectroscopy. Analysis of the attack morphology by scanning electron microscopy.
2	Growth and corrosion resistance of anodic films on Al and Mg alloys.
2	Passivation and corrosion resitance of Ti and Ti alloys, and of carbon and stainless steel.