UNIVERSITÀ DEL SALENTO

CORSO DI LAUREA LM56 –

CdLM Materials Engineering and Nanotechnology

SCHEDE INSEGNAMENTI DIDATTICA EROGATA
a.a. 2020/2021

UNIVERSITÀ DEL SALENTO

SCHEDA INSEGNAMENTO

Batteries and fuel cells

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	ING-IND/21
Docente	Patrizia Bocchetta
Crediti Formativi Universitari	9
Ore di attività frontale	81
Ore di studio individuale	144
Anno di corso	I anno
Semestre	I
Lingua di erogazione	Inglese
Percorso	PERCORSO COMUNE

Prerequisiti	Basic knowledge of physics and chemistry
Contenuti	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/experimental practice.
Obiettivi formativi	Knowledge and understanding The course provides the students with 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.
Metodi didattici	The course consists of frontal lessons, numerical and experimental exercises. Class contents will be given manually 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.
Modalità d'esame	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 characteristic activities 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.
Programma	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.
Testi di riferimento	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.
Altre	https://www.unisalento.it/scheda-utente/-

informazioni utili	/people/patrizia.bocchetta/didattica

SCHEDA INSEGNAMENTO

Chemistry II

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	CHIM/07
Docente	Giuseppe Agostino Mele
Crediti Formativi Universitari	9
Ore di attività frontale	81
Ore di studio individuale	144
Anno di corso	I anno
Semestre	I
Lingua di erogazione	Inglese
Percorso	PERCORSO COMUNE

Prerequisiti	Basic knowledge of chemistry and physics
Contenuti	The aim of this subject is to introduce students to the molecular-level understanding of the physicochemical properties of organic substances aimed at characteristics of materials and nanomaterials. The course will be tailored to master students with a specific background and interest in material sciences and technologies, industrial chemistry, chemical engineering. The overall aim of the course is to train the students in the basic concepts and technologies related to molecular materials possessing useful functional properties. Particular attentions will be devoted to responsive and adaptive materials and to the correlation between the (nano)structure of the molecular components and the functional properties of the hybrid materials.
Obiettivi formativi	After completing this course, the student should be able to: - Define what constitutes an organic compound. Apply the naming and drawing conventions to describe different classes of organic compounds. - Describe the range of molecular structures found among organic compounds. - Describe the physical structure of chemical isomers. - Manage general and organic chemistry issues in general. - Understand the principles and managing the results deriving by application of spectroscopic techniques mainly devoted to the characterization of organic materials.
Metodi didattici	The course consists of frontal lessons by using slides and classroom simulation of experiments. The frontal lessons are aimed at improving students' knowledge through the presentation of theories, models and methods. Part of the practice-oriented course will be focused on the application of

	spectroscopic techniques for analysis of organics and hybrid materials in general.
Modalità d'esame	In the final exam will be discussed the topics presented during the lectures as well as to provide a full structural interpretation of FT-IR, MS, 1H- and 13C-NMR spectra to elucidate the structures of an unknown compound.
Programma	Covalent bonds and shape of molecules (2 hours). Acids and bases (2 hours). Alkanes and Cycloalkanes (2 hours). Alkenes (2 hours). Alkenes: Reactivity (3 hours). Chirality (3 hours). Alkynes (2 hours). Alkyl halides (3 hours). Alcohols, ethers and thiols (1 hour). Benzene and its derivatives (3 hours). Amines (1 hour). Aldehydes and ketones (2 hours). Carboxylic acids (3 hours). Functional derivatives of carboxylic acids (3 hours). Infrared spectroscopy (6 hours). Mass Spectrometry (6 hours). NMR Spectroscopy (10 hours). Tutorials (27 hours)
Testi di riferimento	McMurry J.E. - Fundamentals of Organic Chemistry Pavia, Donald L., Lampman, Gary M., Kriz, George S Introduction to spectroscopy William H. Brown, Thomas Poon, Introduction to Organic Chemistry, 6th Edition, Wiley
Altre informazioni utili	

UNIVERSITÀ DEL SALENTO

SCHEDA INSEGNAMENTO

Electrochemical Technologies

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	ING-IND/23
Docente	Claudio Mele
Crediti Formativi Universitari	9
Ore di attività frontale	81
Ore di studio individuale	144
Anno di corso	I anno
Semestre	II
Lingua di erogazione	Inglese
Percorso	PERCORSO COMUNE

Prerequisiti	Basic knowledge of calculus, physics and chemistry.
Contenuti	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.
Obiettivi formativi	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.
Metodi didattici	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.
Modalità d'esame	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.
Programma	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
Testi di riferimento	[1] C.H. Hamann, A. Hamnett, V. Vielstich - Electrochemistry [2] V. S. Bagotsky - Fundamentals of Electrochemistry [3] A.J. Bard, L.R. Faulkner - Electrochemical Methods: Fundamentals and Applications [4] P. Pedeferri - Corrosione e protezione dei materiali metallici
Altre informazioni utili	Office Hours: by appointment fixed by e-mail or at the end of the class

UNIVERSITÀ DEL SALENTO

SCHEDA INSEGNAMENTO

PHYSICS OF MATTER MOD. I C.I.

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	FIS/03
Docente	Eleonora ALFINITO
Crediti Formativi Universitari	6
Ore di attività frontale	54
Ore di studio individuale	96
Anno di corso	I anno
Semestre	II
Lingua di erogazione	Inglese
Percorso	PERCORSO COMUNE

Prerequisiti	Sufficiency in calculus, probability theory, linear algebra, electromagnetism
Contenuti	This is a course in theory and models in physics of matter; it aims to furnish some basic knolwedge concerning quantum physics of atoms, molecules and solids.
Obiettivi formativi	Knowledge and understanding The course provides a basis and an opportunity for originality in developing or applying ideas in a material physics research context . Applying knowledge and understanding: The course provides abilities in problem solving applied in new or unfamiliar environments within classical and quantum physics contexts . Making judgements: The course gives the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete data to discriminate between the classical and quantum regime, to evaluate the appropriate set of approximations to be used. Communication Students have to be able to communicate their conclusions and rationale to specialist , by using a technical language based on formulas and theorems, and non-specialist audiences by using a narrative language based on elementary concepts. Learning skills Students are trained to develop creative thinking, critical spirit, and autonomy , by using as a knowledge technique examples and counter-examples. The theoretical approach of the course is a good tool to improve their ability of abstraction

Metodi didattici	teacher-led discussion and assignments
Modalità d’esame	Physics of matter I is only the first modulus of the complete course named Physics of matter. There a single final exam which includes the contents of modulus I and modulus II The exam consists of two cascaded parts: the first part is written test (duration: two hours and a half); the student is asked to solve exercises ; it is aimed to verify to what extent the student has gained the ability to apply theory to solve simple case studies; the second part is an oral test aimed to determine to what extent the student has gained an overall knowledge of the main topics of the course.
Programma	Introduction: Physics and tecnology from the end of 1800 to today (3 hours).Mechanical and electromagnetic waves (2 hours).Special relativity (5 hours). Elements of probability and the Maxwell distribution (5 hours). The quantum nature of light (5 hours). Atomic models and the matter wave (5 hours). Quantum mechanics in one dimension (12 hours). The angular momentum (5 hours). The hydrogen atom, eigenvalues and eigenfunctions (3hours). Quantum statistics (2 hours). Multielectron atoms (2hours). Introduction to molecules (5 hours).
Testi di riferimento	[1] R. Eisberg, R, Resnick, Quantum Physics , J. Wiley and Sons. [2] R.A. Serway, C. J. Moses, C. A. Mojer, Modern Physics , Saunders College [3] M. Born, Atomic Physics , Dover Books on Physics [4] <a href="https://archive.org/search.php?query=creator%3A%22Ronald+Gautreau+%26+William+Savin%22">R. Gautreau, W. Savin, Schaums Theory and Problema in Modern Physics
Altre informazioni utili	This is a course in theory and models in physics of matter; it aims to furnish some basic knolwedge concerning quantum physics of atoms, molecules and solids.

UNIVERSITÀ DEL SALENTO

SCHEDA INSEGNAMENTO

PHYSICS OF MATTER MOD. II

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	FIS/03
Docente	Nicola LOVERGINE
Crediti Formativi Universitari	6
Ore di attività frontale	54
Ore di studio individuale	96
Anno di corso	I anno
Semestre	II
Lingua di erogazione	Inglese
Percorso	PERCORSO COMUNE

Prerequisiti	Knowledge and understanding of the concepts tought in PHYSICS OF MATTER MOD. I (LM56)
Contenuti	This is the Modulus II of the course named Physics of Matter . The Mod. II is a graduate level introductory course to the fields of atomic, molecular and condensed matter physics. It aims to present the main properties of atoms, molecules and solids, along with their detailed theoretical description/explanation based on the concepts of quantum mechanics and solid state physics. In particular, the origin and properties of bonds in both molecules and solids are presented, with emphasis - for solids - on metals and metal properties. Special emphasis is placed thoughout this Course modulus on the interaction of atoms and (crystalline) solids with electromagnetic radiation (X-rays) and its use in the physical-chemical and structural characterization of materials. Theoretical concepts introduced during the lectures are complemented by Laboratory classes dealing with practical sessions on X-ray fluorescence and X-ray diffraction measurements on crystalline materials.
Obiettivi formativi	After the Course the student will be able to describe major physical properties of atoms, molecules and solids using the principles and laws of quantum mechanics. In particular, the student will be able to: - Describe and understand electronic configurations of many-electron atoms, their energy levels and angular momentum states; understand the origin and types of molecular bonds; - Understand and utilize X-ray absorption and fluorescence spectroscopy to identify chemical elements in a given material; - Identify solids according to the type of bonds between atomic constituents; - Describe and understand the origin of the metals

	electric/thermal properties and their consequences; - Describe and identify major crystal structures and the spatial arrangements of constituent atoms/ions/molecules within them; - Understand the use of X-ray diffraction for the structural characterization of crystalline materials.
Metodi didattici	The Course is carried on through classroom theoretical lectures (about 90% of the total teaching hours) and practical Laboratory sessions (about 10% of the teaching hours) , the latter focussing on the applications of X-ray fluorescence for determining the materials chemical composition and the sue of X-ray diffraction measurements in the study of crystalline materials.
Modalità d'esame	Physics of Matter Mod. II is the second modulus of the Course named Physics of Matter . There a single final exam which includes the contents of Modulus I and Modulus II. The exam consists of two cascaded parts: the first part is a written test (duration: two hours and a half); the student is asked to solve exercises; it is aimed to verify to what extent the student has gained the ability to apply quantum theory to solve simple case studies; the second part is an oral examination/colloquium aimed at determining to what extent the student has gained an overall knowledge of the topics treated within the course.
Programma	Many-electron atoms, X-ray absorption and fluorescence of atoms, Laboratory I (XRF and microanalysis for analysis of materials chemical compostion), Bonds in molecules, Introduction to Condensed Matter Physics, Chemical bonds in solids, Classical description of electric conduction in metals, Electrons contribution to thermal and thermo-electric properties of metals, Quantum theory of electrons in metals, Elements of crystallography, X-ray diffraction of crystals, Experimental methods of X-ray diffraction on crystals, Laboratory II (Practical X-ray diffraction on crystals).
Testi di riferimento	1. Fundamental University Physics Vol. 3 Quantum and Statistical Physics (M. Alonso E.J. Finn), Addison Wesley (1968). 2. Solid State Physics (N.W. Ashcroft N.D. Mermin), Holt-Saunders International Editions (1976). 3. Introduction to Solid State Physics (C. Kittel), Thomson Press (2003).
Altre informazioni utili	

UNIVERSITÀ DEL SALENTO

SCHEDA INSEGNAMENTO

Science, Technology and Sustainability of Polymers

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	ING-IND 22
Docente	Mariaenrica Frigione
Crediti Formativi Universitari	12
Ore di attività frontale	108
Ore di studio individuale	192
Anno di corso	I anno
Semestre	II
Lingua di erogazione	Inglese
Percorso	PERCORSO COMUNE

Prerequisiti	Knowledge of disciplines belonging to a Bachelor Degree in Industrial Engineering or Materials Science are required to the Students: Chemistry, Physics and Science and Technology of Materials.
Contenuti	The course aims at providing students a comprehensive knowledge of Science and Technology of (natural or synthetic) polymers: from their synthesis, to their processing procedures and techniques, their macroscopic and microscopic properties and characteristics in both solid and liquid states, their durability, degradation/biodegradation in different environmental conditions, LCA (Lyfe Cycle Assessment) techniques applied to polymeric materials and their final disposal. Specific examples of natural (i.e. wood, bio-based polymers) and technologically advanced polymers, or classes of polymers, will be illustrated. Issues related to sustainability of polymers and the impact of waste plastic on the (ground/marine) environment will be discussed, presenting case studies of innovative researches aimed at studying, preventing/limiting the pollution due to waste plastics or of polymers employed to aid the environment. Part of the course will be devoted to the characterization methods and techniques for polymers, with related laboratory experiences.
Obiettivi formativi	Knowledge and understanding. Students must have a solid background with a broad spectrum of basic knowledge related to science, technology and sustainability of (natural or synthetic) polymers: • the students must have the basic cognitive tools to think analytically, critically and to correlate information's needed to analyze, characterize, process, select a polymeric material, identify for it an appropriate recycling route; • they must have solid knowledge of science, technology and sustainability of (natural or synthetic) polymers;

	• they must be able to find and manage any information required on a specific (natural or synthetic) polymer, or a blend of polymers, on textbooks, handbooks, database. Applying knowledge and understanding. After the course the student should be able to: 1) Recognize the main differences, characteristics and features of the three classes of polymers, i.e. thermosetting, thermoplastic and elastomers. 2) Select the appropriate technique and processing conditions for a specific (natural or synthetic) polymer, or a blend of polymers. 3) Identify the relationship between chemical-physical, microstructural characteristics and macroscopic properties of different polymers (including bio-based ones) belonging to the three classes of polymers. 4) Select a proper polymeric material, or a blend of polymers, for a specific application. 5) Select the proper range of service temperature for a polymer, or a blend of polymers. 6) Identify the proper methods and techniques required to characterize a specific polymer, or a blend of polymers, in relation to the specific final use. 7) Analyze the results of an experimental test aimed at characterizing a specific property of a (natural or synthetic) polymer/blend of polymers. 8) Distinguish between the degradation and biodegradation processes, the conditions and environments in which they occur, respectively. 9) Propose a method/technique for the recycle of waste polymers in order to prevent them to be landfilled. Making judgments. Students are guided to learn critically everything that is explained to them in class, to select the more appropriate solution (of a polymer/blend of polymers, or of a method/technique to characterize, process or recycle procedure) for any specific application/requisite and to analytically justify any choice in comparison with available alternatives, taking into account also the eco-sustainability concepts involved in the different choices. Communication. The students must be able to communicate with a varied and composite audience, not culturally homogeneous, in a clear, logical and effective way and with the appropriate terms, using the methodological tools acquired and their scientific knowledge. The course promotes the development of the following skills of the student: ability to expose with the appropriate specialist vocabulary any topic related to science, technology and sustainability of polymers; ability to describe and analyze the proper solution for any specific application/requisite; ability to illustrate the results of an experimental test performed on a polymeric material, ability to discuss on issues related to their disposal with environmental implications. Learning skills. Students must acquire the critical ability to relate, with originality and autonomy, to the typical problems of science, technology and

	sustainability of polymers, and in general, cultural issues related to other similar areas. They should be able to develop and apply independently the knowledge and methods learnt with a view to possible continuation of studies at higher (doctoral) level or in the broader perspective of cultural and professional self-improvement of lifelong learning. Therefore, students should be able to switch to exhibition forms other than the source texts in order to memorize, summarize for themselves and for others, and disseminate scientific knowledge.
Metodi didattici	The course consists of theory lessons, seminars, laboratory experiences, exercitations, visits to industrial plants and/or research laboratories. The theory lessons, carried out by using slides of other didactic material made available to students, always the day before (at least) of the lesson, are aimed at improving their knowledge and understanding through the illustration of definitions, assumptions, models and methods; students are invited take part to the lesson with autonomy of judgment, by asking questions and presenting examples. The seminars are aimed at giving an insight on some selected (updated every year) topics on science and technology of polymers and on issues related to sustainability and environmental impact of waste plastics. The laboratory experiences are aimed at illustrating the main characterization techniques, testing machines and equipment employed to analyze and characterize polymeric materials. The exercitations in classroom are aimed at illustrating how to analyze, report in a graph/table and critically discuss the results of an experimental test performed on a polymeric material. Visits to industrial plants and/or research laboratories are aimed at illustrating the on field application of what the students learn during lessons.
Modalità d'esame	Final (oral) exam The student is asked to describe for a specific (natural or synthetic) polymer, or a blend of polymers, one or more of the following: synthesis, appropriate processing techniques, main properties and characteristics, characterization measurements and techniques and discussion of relative results, durability feature, biodegradation paths, LCA and environmental impact, recycling alternative methodologies. The student is also asked to supply alternatives for a polymeric material, for a characterization technique or for a technological method taking into account a specific goal (application, characterization, recycling). In the evaluation of the exam, the following elements will be taken into consideration: the logical route followed by the student in solving the proposed issue; the correctness of the procedure used to address the question and provide a solution; the adequacy of the proposed solution in relation to the competencies that the student is supposed to have acquired; the capacity to make connections among the different topics covered in the course; the use of an appropriate technical language.
Programma	Theory Lessons: 1) Polymer's Chemistry. Molecular Structure of polymers. Polymeric solutions: rules for polymer solubility in solvents. Molecular weight and measurements. Gel Permeation Chromatography. Polymerization reactions. Step-growth polymerization. Chain polymerization. 2) Polymer's physics. Classification of polymers with examples. Glassy state of

	polymers. Characteristic temperatures for polymers. Glass transition temperature. Crystalline state of polymers. 3) Thermal characterization of polymers. Instruments and techniques for thermal analysis of polymers. Properties measured with thermal analysis. 4) Rheology and rheological analysis for polymer characterization. Classification of fluids on the basis of their rheological properties. Viscosity measurements and relative instruments. Rheological instruments employed for characterization of polymers. 5) Mechanical Properties of polymers. Standard tests and instruments for the characterization of the mechanical properties of polymers. Dynamic-mechanical properties. 6) Processing of polymers. Main industrial techniques and instruments for the processing of polymers. Characteristics of final products. 7) Durability and environmental aging of polymers. Chemical Aging. Physical Aging. Weathering. Natural and accelerated aging. Case studies. 8) Degradation and Biodegradation processes: conditions and environments, mechanisms. Biodegradable polymers. 9) Natural polymer (composite): Wood. Definitions, characteristics and properties of composite and nanocomposite materials. Wood structure at different levels of magnitude. Influence of water/moisture content on wood properties. Mechanical properties of wood: standard tests, specimens, instruments and results. Durability of wood. 10) Circular economy concepts applied to polymers. Bio-based polymers and bio-composites: production, properties, applications. Case studies. 11) LCA (Lyfe Cycle Assessment) techniques applied to polymeric materials. Issues related to sustainability of polymers, impact of waste plastic on the (ground/marine) environment. Case studies. 12) Recycling methodologies for polymers. Advantages and technological limits for each recycling method. Case studies for recycling of thermoplastic, thermosetting and elastomeric polymers. 13) Case studies of polymers employed to aid the environment. Laboratory Experiences: Thermal, Mechanical characterization of polymers. Scanning Electric Microscopy (SEM) to analyze Polymers and Wood. Exercitations: analysis and discussion of the results from (thermal, mechanical) tests performed on different polymers. Seminars held by experts. Visits to industrial plants and/or research laboratories (when possible).
Testi di riferimento	L.H. Sperling, 'Introduction to Physical Polymer Science', John Wiley, 2006. F.W. Billmeyer, 'Textbook of Polymer Science', John Wiley & Sons Inc., 1984. S. Bruckner, G. Allegra, M. Pegoraro, F. La Mantia, "Scienza e Tecnologia dei Materiali Polimerici", Edises, 2007. U.W. Gedde, 'Polymer Physics', Chapman & Hall, 1996. F. Rodriquez, 'Principles of Polymer Systems', McGraw Hill, 1989. A.W. Birley, B. Haworth, J. Batchelor, 'Physics of Plastics', Hanser Publishers, 1992. J. Mark, K. Ngai, W. Graessley, L. Mandelkern, E. Samulski, J. Koenig, G. Wignall, "Physical Properties of Polymers", Cambridge University Press. Slides and other didactic material provided by the teacher.
Altre	Prof. Frigione receives students upon appointment. Contact her at the end of

informazioni utili	each lesson or by e-mail: mariaenrica.frigione@unisalento.it. The students can apply for the exam on Web-VOL system.

SCHEDA INSEGNAMENTO

Transport phenomena II

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	ING-IND 24
Docente	Carola Esposito Corcione
Crediti Formativi Universitari	6
Ore di attività frontale	54
Ore di studio individuale	96
Anno di corso	I anno
Semestre	II
Lingua di erogazione	Inglese
Percorso	PERCORSO COMUNE

Prerequisiti	Sufficiency in calculus, linear algebra
Contenuti	The course is focused on the study of the transport phenomena occurring in fluid/solid materials: mass, heat and momentum transfer. These phenomena greatly regulate and control all the processes (transformation, production, manufacture, etc.) involving materials in their whole life cycle. The course will illustrate the use of: balances (of mass, energy and momentum), both in microscopic anche macroscopic scales in turbulent flow; transport coefficients (friction, heat and mass) between different phases; empirical correlations for turbulent flow. Several case studies will be presented in the course, in order to illustrate the practical use of the mathematical equations introduced in the lessons.
Obiettivi formativi	Knowledge and understanding The course is focused on the study of the These phenomena greatly regulate and control all the processes (transformation, production, manufacture, etc.) involving materials in their whole life cycle. The course will illustrate the use of: balances (of mass, energy and momentum), both in microscopic and macroscopic scales in turbulent flow; transport coefficients (friction, heat and mass) between different phases; empirical correlations for turbulent flow. Several case studies will be presented in the course, in order to illustrate the practical use of the mathematical equations introduced in the lessons. Applying knowledge and understanding: The course provides abilities in transport phenomena problem solving applied in materials engineering field. Making judgements: The course gives the ability to integrate knowledge and handle complexity, and to solve transport phenomena problems occurring in fluid/solid materials: mass, heat and momentum transfer.

	Communication Students have to be able to communicate their conclusions and rationale to specialist , by using a technical language based on formulas and theorems, and non-specialist audiences by using a narrative language based on elementary concepts. Learning skills Students are trained to develop creative thinking, critical spirit, and autonomy , by using as a knowledge technique examples and counter-examples. The theoretical approach of the course is a good tool to improve their ability of abstraction
Metodi didattici	Theoretical and practice lessons
Modalità d'esame	written exam
Programma	Theoretical lessons : Moment Transfer in laminar and turbolent flow. Dimensional analysis of the conservation equations. Dimensionless groups : definitions and physical meant. Case study : flow past immersed sphere. Distribution of velocity in turbulent flow. Mediated expressions for the moment conservation equations. Heat Transfer in laminar and turbolent flow. Case studies : heat conduction in a cooling wing, natural heat convection. Dimensional analysis of the conservation equations. Dimensionless groups : definitions and physical meant. Distribution of temperature in turbulent flow. Mediated expressions for the heat conservation equations. Dimensional analysis technique. Transport coefficient for isothermal systems. Coefficient for moment transfer : friction factor. Transport in pipes and past immersed objects. Correlations between dimensionless groups of the moment transport. Transport coefficient for non isothermal systems. Heat transfer coefficient. Transport in pipes and past immersed objects. Dimensionless groups for natural and forced heat convection. Correlations between dimensionless groups of the heat transport. Transport coefficient for multi- components systems. Mass transfer coefficient. Transport in pipes and past immersed objects. Dimensionless groups for natural and forced mass convection. Correlations between dimensionless groups of the mass transport. Macroscopic balances Macroscopic balances for isothermal and non isothermal systems with one ore more components. Mass macroscopic and moment balance. Macroscopic balance of energy and mechanic energy (Bernoulli equation). Practice: Transport problems in steady and non steady state. Solution of balance and transport equations for problems in steady and isothermal state with one or more components.

	Solution of the conservation equations for the non steady state. Solution of the transport problems for isothermal and non isothermal systems with one or more components. Solution of steady and non steady state problems, using macroscopic balance for Macroscopic balances
Testi di riferimento	R. B. Bird, W. E. Stewart, E. N. Lightfoot, Transport phenomena, Casa Editrice Ambrosiana. L. Theodore, transport phenomena for engineers, International Textbook Company, U.S. A. S. Foust, L. A. Wenzel, C. W. Clump, L. Maus, L.B. Andersen, I principi delle operazioni unitarie, Editrice Ambrosiona, Milano.
Altre informazioni utili	

UNIVERSITÀ DEL SALENTO

SCHEDA INSEGNAMENTO

Ceramics materials

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	Ing-Ind/22
Docente	Antonio Licciulli
Crediti Formativi Universitari	6
Ore di attività frontale	54
Ore di studio individuale	96
Anno di corso	II anno
Semestre	I
Lingua di erogazione	Inglese
Percorso	PERCORSO COMUNE

Prerequisiti	Students are requested to revive chemistry, physics, materials fundamentals, electromagnetism
Contenuti	The course provides a thorough understanding of ceramic and glassy materials. The student will be able to assess whether, when and how to suggest the use of ceramic materials in different application contexts. The criteria for the engineering design and affidabilistic approach on ceramic materials will be disclosed.
Obiettivi formativi	The course should enable the students to: * Identify the role of ceramic materials in technological devices and in everyday life. * Identify the functional and structural properties of ceramic materials and learn how to recognize their properties starting from sensory perceptions ending up to analytical testing. * Quantify the engineering performance of ceramics: strength, stiffness, toughness, transparency, opacity, refractoriness, thermal and electrical conductivity and certify their suitability for specific uses. * Acquire a working method for the identification of the material and combination of materials capable of offering the best engineering solution
Metodi didattici	The course includes plane lecturing on scheduled program plus laboratory experience, ceramic forming and sintering design by rapid prototyping, sol-gel slip casting Attention will be given to applications and markets: ceramics for aerospace, electronics, medicine, energy, glass technology Guided tours in research laboratories and companies are a part of teaching method An introduction on resources resource scouting will be give: Databases,

	internet, fairs, books, magazines, exhibitions Meet experts in seminars
Modalità d'esame	The student is evaluated by the commitment and interest with which he follows the theoretical lectures and laboratory experiences. The student at the end of the course will prepare a monograph or a report on experiences of laboratory. A final oral examination will give the final vote.
Programma	Traditional ceramics, glasses, advanced ceramics: taxonomy and classes. Description of the microstructure of the main ceramics: wurtzite, zin blende, cesium chloride, corundum, fluorite perovskite, garnet, graphite, diamond, amorphous carbon and carbon fibers. Silicates: tectosilicates and feldspars, phyllosilicates, zeolites clays and their properties: intercalation and chemical reactivity and their properties. Ceramics and porcelain from silicates: the ternary phase diagram. Density, microporosity mesoporosity and macroporosity, evaluation and applications. Mechanical properties of ceramics, theoretical strength, Griffith model of fracture for brittle materials, toughening mechanisms in monolithic and ceramic composites. Weibull probabilistic approach to the mechanical performace of ceramics. Electrical and magnetic properties of ceramic: dielectric constant, contributions to the polarizability, electrical conductivity in ceramic conductors and semiconductors. Solid state gas sensors, fuel cells, piezoceramics, ferroelectric and ferromagnetic ceramics. Sintering: definition, types and stages of sintering. Solid state sintering: densification from diffusion transport from grain boundaries, lattice, surface diffusion and vapor. Viscous sintering and Frenkel model. The sintering diagram. Ceramic powders: Bayer process for the preparation of alumina, and Atchenson process for the preparation of silicon carbide. Methods for sieving, sizing calcining ceramic powders. Properties of ceramic suspensions: zeta potential, viscosity, flocculation deflocculation. Forming of ceramic by wet and dry methods: slip casting, uniaxial and isostatic pressing, injection moulding. Rapid prototyping techniques: selective laser sintering, laminated object manufacturing, laser stereolithography. Ceramic matrix composites: ceramic fibres and classification of reinforcements and preforms. The role of fiber-matrix interface. Materials in the glassy state: models and prediction of amorphous solid formation. The furnaces for glass melting and raw materials selection. Production of glass fibers and cables. Glass processing techniques: etching, fusing, blowing, pressing, drawing. Flat glass: production processes, thermal and chemical tempering and surface hardening. Safety glass, tempered glass. Special glasses: low-emissivity, solar glass, anti-reflective, fireproof glasses. Color: Definition absorption phenomena, emission, reflection and luminescence. The color in the ceramic and in the glasses, vibrational model in ionic solids, the transition metals, the rare earths. Applications and markets for structural ceramics, electroceramics, coatings, bioceramics, ceramics for energy, membranes, ceramic filters, ceramics for aerospace, telecommunications materials.

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	Bioceramics and biological tissue response: definitions and classifications. The biogenic materials, and the "ceramic" materials of natural origin. Implants, prosthesys, scaffolds, films the range of ceramic biotechnological solutions.
Testi di riferimento	Fundamentals of Ceramics, Michel Barsoum, M.W Barsoum, 2002 CRC Press Modern Ceramic Engineering, D. W. Richerson, M. Dekker inc., 1990 Mechanical properties of ceramics, J. Wachtman et al, Wiley e Sons 2009 Introduction to the principles of ceramic processing, J.S. Reed J. Wiley e Sons 1988 Electroceramics, A.J. Moulson, J.M. Herbert, Chapman and Hall 1990
Altre informazioni utili	

UNIVERSITÀ DEL SALENTO

SCHEDA INSEGNAMENTO

COMPOSITE AND NANOCOMPOSITE MATERIALS

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	ING-IND/22
Docente	Antonio greco
Crediti Formativi Universitari	6
Ore di attività frontale	54
Ore di studio individuale	96
Anno di corso	II anno
Semestre	I
Lingua di erogazione	Inglese
Percorso	PERCORSO COMUNE

Prerequisiti	knowledge of solid mechanics and materials science and technology
Contenuti	This course is aimed at providing the basics of composites and nanocomposites materials in view of their application in different engineering fields, using a strong interdisciplinary approach. Competences on polymer matrices and reinforcements, mechanics of anisotropic materials, fabrication technologies of thermoplastic and thermosetting matrix composites are provided.
Obiettivi formativi	Knowledge and understanding: The course provides the basis of knowledge to understand and solve complex new problems in design and processing of composite materials accounting for anisotropy and reactive processing Applying knowledge and understanding The student will be able to apply the basic knowledge on mechanics of anisotropic materials to the design of simple structural elements. A multidisciplinary approach is presented accounting for chemical, materials and mechanical engineering aspects. Making judgements Simplification and synthesis of complex problems is presented in order to promote the judgement and evaluation capabilities of the students Communication The course promotes the development of the following skills of the student: ability to expose in precise and formal terms an abstract model of concrete problems, identifying the salient characteristics of them and discarding the inessential characteristics; ability to describe and analyze an efficient solution for the problem under consideration. A seminar on composite properties is assigned to students Learning skills

	Autonomous learning is promoted thanks to the use of: different books and slides, numerical methods, homework exercise to be solved in groups of two.
Metodi didattici	The course is made up of frontal lessons for about 45 hours, and about 10 hours practice with a software implementing micro and macromechanic of composite materials. 10 more hours of laboratory are foreseen, in order to highlight the relevance of anisotropy in mechanical testing, and provide a practical demonstration of the main technologies for composite processing
Modalità d'esame	Oral exam after a seminar on composite properties and a homework .
Programma	Introduction: matrix and reinforcements. Reinforcement materials: Physical, chemical, mechanical properties of carbon, glass, aramide, basalt, polymeric and natural fibers. Surface treatment of fibers for improved adhesion Sandwich structures: Core materials: foams and honeycombs. Mechanical properties of sandwich structures. Micromechanics Fiber-matrix interface. Characterization of fiber-matrix adhesion. Calculation of the elastic and ultimate properties of unidirectional laminae from the properties of matrix and fibers Macromechanics Elastic properties of a lamina of arbitrary orientation. Failure criteria Macromechanical behavior of a laminate Lamination theory. Special cases of laminate stiffness. Mechanical behaviour of anisotropic laminates (Helius Composite Design) Nanocomposites Nanofillers, geometries and materials. Preparation of nanocomposites. Characterization of nanocomposites: improvement of properties and analytical prediction of properties.
Testi di riferimento	P.K. Mallick, "Fiber reinforced composites'", Marcel Dekker R.M. Jones, "Mechanics of composite materials", McGraw Hill Didactic aids (lecture slides) provided by the teacher
Altre informazioni utili	

UNIVERSITÀ DEL SALENTO

SCHEDA INSEGNAMENTO

HEAT AND MASS TRANSFER PHENOMENA IN COMPOSITES AND POLYMERS

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	Ing-Ind/24
Docente	Alfonso Maffezzoli
Crediti Formativi Universitari	9
Ore di attività frontale	81
Ore di studio individuale	144
Anno di corso	II anno
Semestre	I
Lingua di erogazione	Inglese
Percorso	PERCORSO COMUNE

Prerequisiti	Knowledge of transport phenomena and polymer physics and chemistry.
Contenuti	This course is aimed to apply the basic knowledge of transport phenomena to the mathematical modeling of processing of composite materials. Competences on thermosetting polymer matrices, their reactivity and the kinetics of curing are also provided. Basic elements of finite element (FE) numerical solution of heat balance equations is provided. The optimization of composite processing is performed adopting a FE tool. In the last part of the course sorption and mass diffusion in polymrs is analyzed as an application of the basic knowledge of transport phenomena
Obiettivi formativi	Knowledge and understanding: The course provides the basis of knowledge to understand and solve complex new problems in materials processing and in mass and heat diffusion, applying ideas often in a research context Applying knowledge and understanding The student will be able to solve heat and mass balances, applied to materials processing, using approximate solution or numerical methods. A multidisciplinary approach is presented accounting for chemical, materials and mechanical engineering aspects. Making judgements Dimensionless and approximate methods are presented in order to promote the judgement and evaluation capabilities of the students Communication The course promotes the development of the following skills of the student: ability to expose in precise and formal terms an abstract model of concrete problems, identifying the salient characteristics of them and discarding the inessential characteristics; ability to describe and analyze an efficient solution for the problem under consideration.

	Learning skills Autonomous learning is promoted thanks to the use of: different books and slides, numerical methods, homework exercise to be solved in groups of two
Metodi didattici	Lessons, practice with a Finite Element program for the solution of differential equations, visit to an industrial plant. Self evaluation tests with Kahoots after every topic
Modalità d'esame	Interview after a homework . A homework regarding modeling topics, and an associated finite element solution of the related differential equations, is assigned to students. During the exams the homework is discussed and if the results are satisfactory an interview is started with questions regarding the main topics of the course
Programma	Introduction, thermosetting composite matrices (12 hours). Basic principles of the processing of thermosetting matrix composites: autoclave lamination as case study (20 hours). Process modeling through numerical solution of differential equations (10 hours). Modeling approach to filament winding, pulrusion, RTM and other processes (16 hours). Processing of thermoplastic composites (8 hours). Visit to industrial plants (3 hours). Mass transport in polymers: technological and modeling issues (12 hours). Industrial plant visits are programmed. A full day to the Journée européenne de composites (JEC) in Paris (France), the most relevant world fair on materials and processes for composites, is organized if adequate financial support is provided by University to students.
Testi di riferimento	Slides in *.ppt format available at https://formazioneonline.unisalento.it/ Crank "Mathematics of diffusion" D. S. Burnett "Finite Element Analysis: From Concepts to Applications" P.K. Mallick "Fiber-Reinforced Composites: Materials, Manufacturing, and Design"
Altre informazioni utili	Write an email to the teacher (alfonso.maffezzoli@unisalento.it) for an appointment or questions The link to participate to on-line interviews is: https://teams.microsoft.com/l/team/19%3aacd7a95cfc284755a9abd13166db8c77%40thread.tacv2/conversations?grou

UNIVERSITÀ DEL SALENTO

SCHEDA INSEGNAMENTO

Non Ferrous metallurgy

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	ING/IND 21
Docente	Paola Leo
Crediti Formativi Universitari	6
Ore di attività frontale	54
Ore di studio individuale	96
Anno di corso	II anno
Semestre	I
Lingua di erogazione	Inglese
Percorso	PERCORSO COMUNE

Prerequisiti	Metallurgia di base
Contenuti	Il corso sviluppa contenuti relativi alla microstruttura, proprietà meccaniche, processo, metallurgia fisica e applicazioni ingegneristiche delle leghe non ferrose. Particolare attenzione è dedicata alle relazioni microstruttura / proprietà, processo/ proprietà e al ruolo dei trattamenti termici sull'evoluzione della microstruttura.
Obiettivi formativi	Dopo il corso lo studente dovrebbe essere in grado di: 1) Identificare le proprietà, le applicazioni e i limiti delle principali leghe non ferrose; 2) Riconoscere le principali caratteristiche microstrutturali e meccaniche indotte da processi di fusione, deformazione plastica e metodi di giunzione; 3) Identificare il ruolo dei parametri di processo (saldatura, fusione, deformazione plastica, stampa 3D) sull'evoluzione e le proprietà microstrutturali; 4) Applicare metodi di rafforzamento e trattamenti termici; 5) Riconoscere il ruolo dei cicli termici di processo sull'evoluzione della microstruttura. 6) Orientarsi nella scelta progettuale delle più utilizzate leghe non ferrose per applicazioni a bassa e alta temperatura.
Metodi didattici	Lezioni Frontali, Laboratorio, Progetti Individuali, Analisi di casi di studio
Modalità d’esame	Parte scritta su argomenti teorici Parte orale sulla parte progettuale
Programma	Lezioni Frontali: 1) Introduzione sulle leghe non ferrose in termini di principali caratteristiche

	microstrutturali, proprietà, applicazioni, processo (1h) 2) Richiami sulla cristallografia, difetti, meccanismi di rafforzamento (3 ore) 3) Metallografia e tecniche sperimentali (3 ore): a) Preparazione del campione per la microscopia ottica b) microscopio ottico c) Test di durezza 4) Metallurgia fisica: a) Principi di solidificazione: microstruttura, trattamenti termici, difetti (8 ore). b) Deformazione plastica, evoluzione microstrutturale e trasformazioni di fase allo stato solido: Recupero e ricristallizzazione statici e dinamici (3 ore). c) Indurimento per precipitazione (6 ore). d) Evoluzione microstrutturale indotta da cicli termici di processo (3 ore) Casi di studio sugli argomenti precedenti. 5) Leghe di alluminio (4 ore) Leghe di alluminio da deformazione plastica: microstrutture e trattamenti termici, designazione di leghe e dei trattamenti termici, rafforzamento per incrudimento, leghe non trattabili termicamente, leghe trattabili termicamente, giunzioni. Applicazioni. Casi di studio su argomenti di cui sopra Leghe di alluminio da getto: microstrutture e trattamenti termici, designazione di leghe e trattamenti termici, leghe basate sul sistema alluminio-silicio, leghe basate sul sistema alluminio-rame, leghe alluminio-magnesio, leghe alluminio-zinco-magnesio. Applicazioni. Casi di studio sugli argomenti precedenti. 6) Leghe di magnesio (2 ore) Microstrutture e trattamenti termici, designazione delle leghe e dei trattamenti termici, leghe con e senza zirconio. Casi di studio sugli argomenti precedenti. 7) Leghe di titanio (4 ore) Leghe alfa: microstruttura e proprietà Leghe Alpha / Beta: microstruttura e proprietà Leghe Beta: microstruttura e proprietà Trattamenti termici Applicazioni. Casi di studio su argomenti di cui sopra. 8) Processi innovativi per leghe non ferrose: evoluzione e proprietà della microstruttura (6 ore): Nuove tecniche di giunzione: microstruttura e proprietà Nuove tecniche di rivestimento: microstruttura e proprietà Additive manufacturing: microstruttura e proprietà Casi di studio sugli argomenti di cui sopra. 9) Le leghe non ferrose in campo Biomedico (3) Laboratorio: 1) Lappatura, lucidatura, attacco chimico, attacco elettrolitico, analisi in microscopica ottica, test di durezza e test di trazione applicati alla caratterizzazione microstrutturale e meccanica delle seguenti leghe leggere: 2024,7075,6061, A357, C355, Ti-6Al -4V, WE43, AZ91 (4 ore) 2) Caratterizzazione della microstruttura di getti e saldature di leghe non

	ferrose trattabili termicamente e non: microstruttura, difetti, proprietà meccaniche (2 ore) 3) Trattamento termico di solubilizzazione e invecchiamento applicato a leghe di alluminio e magnesio: curve di invecchiamento a diverse temperature di mantenimento con o senza precedente trattamento termico della soluzione (2 ore) 4) Microstruttura da deformazione plastica e trattamento di recupero e ricristallizzazione applicati alle leghe di alluminio: evoluzione della microstruttura e proprietà meccaniche (2 ore) 5) Trattamenti termici di omogeneizzazione (2 ore): evoluzione della microstruttura e proprietà meccaniche 6) Trattamenti termici della lega Ti-6Al-4V (2 ore) Evoluzione di microstruttura e durezza della lega in seguito a permanenza in temperatura (in campo alfa, alfa +beta, beta) e raffreddamenti a velocità crescenti. Progetto individuale: Nuove tecniche di giunzione / rivestimento / stampa 3D applicate a leghe non ferrose: caratterizzazione microstrutturale e meccanica dei campioni (6-8 ore)
Testi di riferimento	[1] American Society for Metals, Metals Handbook, V. 15, Casting, Metals Park, Ohio, 1988. [2] J.D. Verhoeven, Fundamentals of Physical Metallurgy, Wiley [3] R.W. Hertzberg,Deformation and Fracture Mechanics of Engineering Materials, Wiley [4] M.Tisza, Physical Metallurgy for Engineers, ASM, [5] G.E Dieter, Mechanical Metallurgy, McGraw-Hill [6] I.J.Polmear, Light Alloys, BH [7] W.F.Smith, Structure and Properties of Engineering Alloys,McGraw-Hill [7] G. Lutjering, J. C. Williams,'Titanium', Springer 2nd edition, New York [8] R.W. Messler, Principles of welding, J.Wiley & Son
Altre informazioni utili	

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SCHEDA INSEGNAMENTO

NANOTECHNOLOGIES FOR ELECTRONICS

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	ING-INF/01
Docente	Massimo DE VITTORIO
Crediti Formativi Universitari	6
Ore di attività frontale	54
Ore di studio individuale	96
Anno di corso	II anno
Semestre	II
Lingua di erogazione	Inglese
Percorso	MATERIALS FOR ELECTRONIC APPLICATIONS

Prerequisiti	Background on solid state physics and semiconductor devices is recommended but not mandatory
Contenuti	The course deals with the most advanced technologies at the nanometer and micrometer scale for the fabrication and characterization of electronic, photonic and micro- and nano-electromechanical MEMS/NEMS systems and devices. It describes how micro and nanotechnologies impact different fields and applications such as Information and Communication Technologies (ICT), Energy, Lifescience and Medicine and it shows how the most advanced devices, often employed in our portable and home electronics, such as nanoscale transistors, smart sensors and microelectromechanical systems, are fabricated and tested. During the course several visits to the nanotechnology laboratory of the Center for Biomolecular Nanotechnologies of the Istituto Italiano di Tecnologia, with demonstrations of the available state of the art equipment for front-end (material and device fabrication) and back-end (device packaging, characterization, test) tools, will be done. The course also includes a training on multiphysics finite element method softwares for electronic, photonic and MEMS device design and simulation.
Obiettivi formativi	Knowledge and understanding. Students must have a background in semiconductor crystals and devices and basic background in material science: - the students must have the basic cognitive tools to understand semiconductor crystals and their technology; - they must have knowledge of the electromagnetic waves and how they are applied to microscopy and technology; - they must be able to understand the chemistry behind micro and nanotechnologies;

	Applying knowledge and understanding . After the course the student should be able to: - understand how a micro and nanodevice is designed, fabricated and tested; - how micro and nano fabrication, characterization and packaging tools work; - use simulation software tools to design and predict the operation of an electronic, photonic and microelectromechanical devices and systems; Making judgements. Students are guided to learn critically everything that is explained to them in class, to understand the behavior of the state of the art technologies for electronic and photonic and MEMS devices, and to design new devices. Communication. The students will be stimulated to be able to communicate with a varied and composite audience, not culturally homogeneous, in a clear, logical and effective way, using the methodological tools acquired and their scientific knowledge and, in particular, with and professional and scientific vocabulary. In particular they will be asked to select a state of the art technology, recently proposed in high impact journals, and to make a presentation about it to the classroom. Learning skills Students must acquire the critical ability to understand the behavior of devices at the micro and nanoscale. They should be able to develop and apply independently the knowledge and methods learnt with a view to possible continuation of studies at higher (doctoral) level or in the broader perspective of cultural and professional self-improvement of lifelong learning.
Metodi didattici	The teaching of the course will be a combination of projection of videos and slides and visits to labs with demonstration of state of the art technologies and clean-room equipments.
Modalità d'esame	Oral exam. Discussion on a state of the art nanotechnology for the fabrication of an electronic, photonic or microelectromechanical device.
Programma	Introduction to Nanotechnology. The nanoworld: top-down and bottom-up approaches for nanofabrication (4 hours); Surface and Bulk Micro and Nanomachining: micro and nanotechnologies: electron beam lithography, scanning probe nanolithography, DUV and EUV lithography, X-Ray lithography, wet and dry etching, deposition and growth techniques, 3D laser lithographies, deep etching, LIGA (15 hours). Characterization techniques Electronic microscopy, scanning probe microscopy, microanalisis, spectroscopy (10 hours); Applications of Nanotechnologies: examples of applications of nanotechnologies to electronic, photonic and micro and nanoelectromechanical devices and systems (4 hours);

	Device simulation Finite element (FEM) multiphysics modeling of an electronic, photonic and NEMS/MEMS device or structures (6 hours); Laboratories Laboratories on lithography, nanofabrication and characterization of nanostructures and devices (15 hours): - Visit of clean room and observation of the operation of nanotechnological tools; - Microscopy and characterization of samples and devices with different characterization tools.
Testi di riferimento	[1] Handouts and course notes. [2] Springer Handbook of Nanotechnology.
Altre informazioni utili	

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SCHEDA INSEGNAMENTO

SEMICONDUCTOR PHYSICS AND TECHNOLOGY

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	FIS/03
Docente	Nicola LOVERGINE
Crediti Formativi Universitari	9
Ore di attività frontale	81
Ore di studio individuale	144
Anno di corso	II anno
Semestre	II
Lingua di erogazione	Inglese
Percorso	MATERIALS FOR ELECTRONIC APPLICATIONS

Prerequisiti	Knowledge and understanding of the concepts tought in PHYSICS OF MATTER MOD. I MOD. II (LM56)
Contenuti	
Obiettivi formativi	
Metodi didattici	The Course is carried on through classroom theoretical lectures (about 90% of the total teaching hours) and practical Laboratory sessions (about 10% of the teaching hours) , the latter focussing on the applications of MOVPE and MBE technology to the synthesis of compound semiconductor hetero- and nano-structures.
Modalità d'esame	The exam consists of an oral examination/colloquium aimed at determining to what extent the student has gained an overall knowledge of the topics treated within the course, and its ability to discriminate between different semiconductor technologies, their most relevant areas of applications and understand the fundamental physical-chemical principles behind these technologies.
Programma	Introduction to Semiconductors and their Applications, Crystallography of elemental and compound semiconductors, Electrons band structure of semiconductors, Point defects in semiconductors, Line and plane defects in semiconductors, Phase diagrams of semiconductor compounds, Production of Electronic Grade poly-Silicon, Bulk crystal growth technologies of c-Silicon, Bulk crystal growth technologies of III-V compound semiconductors, Fabrication of Semiconductor Wafers, Epitaxy and epitaxial heterostructures, Liquid Phase Epitaxy, Principles of VPE technology, VPE-chlorides and VPE-hydrides of Si and III-V compounds, VPE-hydrides of II-VI compounds, MOVPE technology of compound semiconductors, Laboratory I: VPE/MOVPE, MBE technology of compound semiconductors, Laboratory II: MBE.
Testi di	Fundamental University Physics Vol. 3 Quantum and Statistical Physics (M.

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riferimento	Alonso E.J. Finn), Addison Wesley (1968). Introduction to Solid State Physics (C. Kittel), Wiley (Chichester, 1991). Handbook of Crystal Growth , Edited by D.T.J. Hurle (North-Holland, Amsterdam-NL, 1993). Vol. 2: Bulk Crystal Growth . Vol. 3: Thin Films and Epitaxy
Altre informazioni utili	

SCHEDA INSEGNAMENTO

BIOMATERIALS

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	ING-IND/22
Docente	In attesa di assegnazione
Crediti Formativi Universitari	9
Ore di attività frontale	81
Ore di studio individuale	144
Anno di corso	II anno
Semestre	II
Lingua di erogazione	Inglese
Percorso	MATERIALS FOR BIOMEDICAL APPLICATIONS

Prerequisiti	Basic knowledge on polymer science and technology is suggested.
Contenuti	The aim of the course is to provide students with basic knowledge on the design of medical devices for given applications, from biomaterial choice to manufacturing technologies. Particular attention is given to the development of the following devices: a) artificial prostheses; b) scaffolds for regenerative medicine and tissue engineering; c) devices for controlled drug release.
Obiettivi formativi	This course aims to highlight the properties of biomaterials affecting their performance as medical implants, scaffolds for tissue engineering and drug delivery devices. At the end of the course, students are expected to: - understand the physiological response to medical implants; - know the principles of scaffold design and related manufacturing technologies; - know the principles of drug delivery design; - identify the most suitable biomaterial(s) for given applications; - know the methods for bulk and surface characterization of biomaterials.
Metodi didattici	The course includes lectures, lab experiences and seminars on selected topics.
Modalità d'esame	Final exam will consists of an oral interview, during which the student is expected to show complete knowledge and comprehension of the topics of the course.
Programma	- Introduction on biomaterials and medical devices. Metals, bioceramics, natural and synthetic polymers (6 ore).

	- Viscoelasticity of polymers and biological tissues. Hydrogels: definition and applications; thermodynamics and kinetics of swelling; crosslink density (rubber elasticity theory) (16 hours). Laboratory activities (4 hours). - Diffusion in polymers and principles of drug delivery devices. Diffusion and erosion-based mechanisms. Examples: hydrogels, micro- and nano-particles. Transdermal drug release devices. Drug targeting for cancer therapy (14 hours). - Physiological response to permanent implants. Definitions and examples of favourable or adverse responses. Wound healing: acute and chronic response. Examples of permanent implants: orthopedic prostheses; contact lenses; stents (8 hours). - Principles of tissue engineering. Scaffold design: structure and properties; porosity, degradation, mechanical properties, manufacturing technologies. Bioreactors; cells for tissue engineering (16 hours). Laboratory activities (5 hours). - Case studies: biomaterials and scaffolds for regeneration of nerves, bone, cartilage, tendons and ligaments. Biomaterials for cell encapsulation (9 hours). - Classification and regulatory issues for medical devices (3 hours).
Testi di riferimento	[1] Pietrabissa, R. Biomateriali per protesi e organi artificiali. Patron Editore. [2] Yannas I.V. Tissue and Organ Regeneration in Adults. Springer [3] Class notes and slides
Altre informazioni utili	

SCHEDA INSEGNAMENTO

CELL TISSUES INTERACTION

Corso di studio di riferimento	LM56 - CdL Magistrale in Materials Engineering and Nanotechnology
Dipartimento di riferimento	Dipartimento di Ingegneria dell'Innovazione
Settore Scientifico Disciplinare	ING-IND/34
Docente	Christian DEMITRI
Crediti Formativi Universitari	6
Ore di attività frontale	54
Ore di studio individuale	96
Anno di corso	II anno
Semestre	II
Lingua di erogazione	Inglese
Percorso	MATERIALS FOR BIOMEDICAL APPLICATIONS

Prerequisiti	Competenze di base in chimica e fisica
Contenuti	l corso fornisce le conoscenze di base sulle interazioni fra le cellule ed i tessuti biologici, con particolare riferimento allo studio delle proprietà rigenerative, introducendo nozioni fondamentali sulla tecniche di ingegneria tissutale. Il corso fornisce inoltre una panoramica sulle problematiche connesse alle tecniche di rigenerazione di tessuti ed organi.
Obiettivi formativi	Conoscenze e comprensione . Al termine del corso, gli studenti devono possedere un ampio spettro di conoscenze di base relative all'interazione fra le cellule ed i tessuti biologici. In particolare: - devono possedere solide conoscenze relative alla relazione fra struttura cellulare e funzione; - devono possedere gli strumenti cognitivi di base necessari alla comprensione dei meccanismi di base dei processi di rigenerazione dei tessuti. Capacità di applicare conoscenze e comprensione. Alla fine del corso lo studente dovrebbe essere in grado di: - Individuare la correlazione esistente tra funzioni cellulari, componenti della cellula e meccanismi di rigenerazione; - Dimostrare di avere acquisito competenze e capacità di valutazione adeguate per la risoluzione in autonomia di problemi concreti inerenti l'interazione fra materiali e tessuti. Autonomia di giudizio. Gli studenti sono stimolati ad individuare le proprietà dei materiali più importanti per determinate applicazioni in campo biomedicale e a pervenire a giudizi originali ed autonomi su

	possibili soluzioni a problemi concreti. Abilità comunicative. Ci si aspetta che gli studenti acquisiscano la capacità di relazionare su tematiche di interazione fra cellule e tessuti biologici con un pubblico vario e composito, in modo chiaro, logico, sintetico ed efficace, utilizzando le conoscenze scientifiche acquisite ed in particolar modo il lessico di specialità. Capacità di apprendimento. Gli studenti devono acquisire la capacità critica di rapportarsi, con originalità e autonomia, alle problematiche tipiche delle funzioni cellulari in relazione alla loro capatità di mettere in atto processi di rigenerazione.
Metodi didattici	Lezioni frontali ed esperienze di laboratorio
Modalità d'esame	Prove In itinere e prova orale finale
Programma	Introduction: cell-matrix interactions, cell-cell interactions, cell-material interactions Structure and function of ECMs Unit cell processes and integrins Repair vs. Regeneration Spontaneous vs. Induced Regeneration Surface of biomaterials and protein adsorption Methods of functionalization and analysis Phenotype changes induced by biomaterials Structural parameters affecting bioactivity Noncooperative cell-matrix interactions Cooperative cell-matrix interactions Tissue response to implants; examples Material biocompatibility Sterilization and its effects on materials and cell-material interactions Laboratory experience: synthesis of sterile biomaterials/scaffolds In vivo synthesis of organs: skin In vivo synthesis of organs: peripheral nerve Simplest synthetic pathways Implants for bone regeneration OR Implants for soft musculoskeletal tissues
Testi di riferimento	Dispense fornite dal docente
Altre informazioni utili	Il docente riceve previo appuntamento da concordare per email.