Materials science and engineering

Academic Year: (2023 / 2024) **Review date: 19-12-2023**

Department assigned to the subject: Materials Science and Engineering and Chemical Engineering Department

Coordinating teacher: VELASCO LOPEZ, FRANCISCO JAVIER

Type: Compulsory ECTS Credits : 6.0

Year : 2 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Chemistry

SKILLS AND LEARNING OUTCOMES

RA1: Acquire knowledge and understanding of the basic general fundamentals of engineering and biomedical sciences.
RA2: Be able to solve basic engineering and biomedical science problems through a process of analysis, identifying the problem, establishing different methods of resolution, selecting the most appropriate one and its correct implementation.
CB1: Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2: Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CG1: Adequate knowledge and skills to analyse and synthesise basic problems related to engineering and biomedical sciences, solve them and communicate them efficiently.
CG3: Knowledge of basic scientific and technical subjects that enables them to learn new methods and technologies, as well as providing them with great versatility to adapt to new situations.
CG4: Ability to solve problems with initiative, decision-making, creativity, and to communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the biomedical engineer's activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG8: Ability to solve mathematical, physical, chemical and biochemical problems that may arise in biomedical engineering.
CG10: Knowledge of the structure, composition, processing, properties and behaviour in service of the different families of materials and their interrelationships. Being able to select materials according to their applications in biomedicine.
ECRT10: Know the structure, composition, processing, properties and behaviour in service of the different families of materials and their interrelationships.
ECRT11: Be able to select materials according to their applications in the different fields of bioengineering.
ECRT12: Knowing the most appropriate standardised tests for the evaluation of the properties and behaviour of materials and analysing and interpreting the results.
CT1: Ability to communicate knowledge orally and in writing to both specialised and non-specialised audiences.

OBJECTIVES

To understand the main principles of materials science and engineering: relationship between structure, chemical bonding, properties, processing and applications.
To know the general properties of the main groups of materials: ceramics, metal, polymers and composites

During the course students will work on the following capabilities:
- Capability to solve complex problems
- Capability to find, understand and discriminate the relevant information to make a proper decission
- Capability to apply multidisciplinary knowledge to solve a given problem
- Capability for team work: to accept tasks and to distribute tasks among classmates to face complex problems

A collaborative attitude will be developed along the course to obtain from other agents skills and knowledge necessary for specific objectives.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Families of materials, applications and selection criteria. Classification of materials and their general properties. Structure, properties and processing: examples. Selection of materials: practical examples. Evolution and competition among materials.

2. Bonding. Ionic bonding and lattice energy. Covalent bond, a review: polar molecules, polarization capacity and polarizability. Metallic bond. Intermolecular forces. Bonding-properties relationship.

3. Diffusion. Mechanisms of diffusion. Steady state diffusion: Fick¿s first law. Non-steady state diffusion: Fick¿s second law. Factors that influence diffusivity. Examples.

4. Crystal structure of metals and defects. Unit cell and crystalline systems. Main metallic structures (BCC, FCC, HCP). Atomic positions, directions and planes in crystalline structures: Miller indices. Linear, planar and volumetric density. Imperfections in real crystals: thermodynamic justification. Point defects: vacancy, interstitial, Schottky and Frenkel. Dislocations, slip systems and plastic deformation. Planar defects: grain boundaries (Hall-Petch relation), stacking faults, twin boundaries. Solid solutions: types, Hume-Rothery rules.

5. Phase diagrams. Basic concepts. Gibbs phase rule. Binary isomorphous phase diagrams. Non-equilibrium solidification: microsegregation. Binary eutectic systems: reaction and microstructure. Other invariant reactions. The Fe-C system: invariant reactions. Eutectoid, hypo and hyper eutectoid steels.

6. Mechanical properties. Uniaxial tensile test: stress-strain curve. Another mechanical tests. Strengthening mechanisms. Fracture and fatigue.

7. Heat treatments. Annealing processes. Isothermal and continuous cooling transformations. Non-equilibrium diffusionless transformation: martensite. Hardenability. Precipitation phenomena.

8. Metals. Importance on bioengineering. Stainless steels. Titanium alloys.

9. Ceramics. Structure of common bioceramics. Properties and processing of ceramics. Glasses in bioengineering.

10. Polymers. Basic definitions, general properties and examples. Classification. Synthesis: addition, condensation, examples. Molecular features. Crystallinity. Factors that affect crystallinity. Mechanical behavior of polymers. Types of polymers: thermoplastic, thermosets, elastomers, comparative study of their properties. Implant polymers. Polymer processing: extrusion, injection, blow molding, rotational molding, thermoforming.

11. Composite materials. Definition and types. Composites in nature. Classification. Types of constituents. Fiber reinforced composites: roles of matrix and reinforcement. Types of fibers: glass, carbon, polyamides. Mechanical behavior of fibers. Structural composites: sandwich, laminates. Elastic behavior: isostress and isostrain conditions. Strength. The role of the interphase. Examples.

12. Additive manufacturing. Concepts and examples.

LEARNING ACTIVITIES AND METHODOLOGY

Master classes, collective tutorials, individual tutorials, homework; oriented to attainment of theoretical knowledge. Problem solving lectures in small groups, laboratory practicals, individual tutorials and homework; oriented to attainment of practical knowledge and skills related with the syllabus.

ASSESSMENT SYSTEM

Cont. Ass.:
45% exams in master class
10% laboratory
Final exam*: 45% global mark.
*It is necessary to obtain 4 as a minimum grade in the final exam to average with continuous assesment

% end-of-term-examination:	45
% of continuous assessment (assigments, laboratory, practicals…):	55

BASIC BIBLIOGRAPHY

- DR Askeland The Science and Engineering of Materials, PWS Pub. Co, 1984
- JF Shackelford Introduction to Materials Science for Engineers, Pearson International Edition, 2009
- MF Ashby, DR Jones Engineering Materials, Elsevier, 2010
- WF Smith and J Hashemi Foundations of Materials Science and Engineering, Ed, McGraw-Hill, 2010

ADDITIONAL BIBLIOGRAPHY

- G. Sharma; A. García-Peñas Nanohybrids, Materials Research Foundations, 2021