1EL4000 – Materials

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Department: DÉPARTEMENT MÉCANIQUE ENERGÉTIQUE PROCÉDÉS
Language of instruction: FRANCAIS, ANGLAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00

Description

- To make 1st year students aware of materials issues and their importance in society, economy and innovation
- Open them to the multidisciplinary nature of the world of materials and make them aware of the scientific and technological barriers around materials (e.g. aeronautics, fuel cells, ITER, electronics beyond Moore's law, energy recovery and transformation, materials for health, biomaterials, MEMS-NEMS, ...)
- To give students the ability to read scientific and technical documents on any material, to extract the characteristics important for a targeted application, and to interpret these elements in relation to the structural, physical and mechanical characteristics of the material
- Show that the choice of a material results from a compromise within a set of constraints: availability of resources, production processes, use properties, life cycle, environmental impact and cost
- To make understand the physical phenomena at the origin of the properties of materials, to propose, through some examples, simple models which capture the essential of the physics of the phenomena and tools which make it possible to apprehend these phenomena, and to give the desire to deepen in more fundamental courses thereafter

Quarter number
SG1 and SG3

Prerequisites (in terms of CS courses)
None

Syllabus
• Introduction : current importance of materials, challenges associated with materials in major societal issues

• Introduction to the main families of materials: definition based on the nature of the chemical bond, resulting and use properties, introduction to the choice of materials
• Structures and phase transformations of materials :
o Order-disorder concepts: from crystal to amorphous via polymers and liquid crystals and how to describe and measure order and disorder
o Defects (0D to 3D): crucial role of the defect in the materials, illustration by various couples defect / property
o Thermodynamic balances and phase diagrams, their role in materials development
• Material properties :
o Mechanical properties related to the structure: plastic deformation mechanisms, material breakage and ruin
o Functional properties related to the structure: thermal and electrical conduction, ferroelectricity, magnetism, optics

Class components (lecture, labs, etc.)
(1 session = 3 hours lesson) except the session 12 that will be 2 hours

- Sessions 1 to 10 : lecture + directed study session
- Session 11 : 3 hours working session
- Session 12 : exam

Grading
Continuous monitoring during the course : 50% of the final grade
- MCQ 25% of the final grade
- summary document produced at the end of the study session on a material and its application: 25% of the final grade.
Final written exam (2 hours): 50% of the final grade

Skill C1 is evaluated through the study session and the final exam, whereas skill C2 is evaluated using the final grade.

Course support, bibliography
Materials of M. Ashby and D. Jones, Introduction to Solid State Physics of C. Kittel

Resources
• Teaching staff (instructor(s) names): Brahim Dkhil, Hervé Duval, Véronique Aubin, Camille Gandiolle, Elsa Vennat, Pierre-Eymeric Janolin, Caroline Toffolon, Christine Guéneau
• Maximum enrollment (default 35 students): 35 students
• Software, number of licenses required: CES Edupack, 100 licenses
• Equipment-specific classrooms : none
Sessions 1.1 and 1.3 are given in French, session 1.4 in English.

Learning outcomes covered on the course

At the end of this course, the student will be able to:

- Analyze the scientific aspects of the overall behavior of a limited-scale system (e.g., isolated part of a complex system), including identification of factors that influence its behavior

How:

o For a given application, describe the constraints and the loadings imposed by that application. Prioritize these constraints to make a choice of materials. Make a multi-criteria material selection.

o For a given material, explain the macroscopic properties according to its atomic arrangement, its defects and its microstructure at different scales

o Read scientific and technical documents on a material, extract important characteristics for a targeted application, interpret these elements in relation to the structural, physical and mechanical characteristics of the material

- Correctly use a model presented in class, in its conditions of validity (model describing a phenomenon, without couplings)

How to:

o use a phase diagram to predict the microstructure of a material according to its thermomechanical history

o use a diffractogram to identify the structure and the atomic arrangement of the analyzed material

o use the model of interaction of dislocations with the microstructure to explain the mechanical behavior of a crystalline material

o use the material toughness criterion to dimension a structure at failure

o interpret the electronic properties of a material to deduce its functional properties, semiconductivity and ferroelectricity

Description of the skills acquired at the end of the course

C1.1 "Knowing how to list the parameters that influence the system under study, the list of elements with which it is related. Identify those that are important to the problem at hand".

C1.2 : "Know how to use a model presented in class in a relevant way (model describing a phenomenon, without couplings)"