ANNEE : 3ème année/ 3rd year - 60 ECTS

SEMESTRE : 1er semestre / 1st Semester - 30 ECTS

UE : Sciences des Matériaux/ Materials Science - 14 ECTS

- EC : Introduction à la science des matériaux / Introduction to Material Science - 2.00 ECTS
- EC : Microstructures. diffusion et diagrammes d'équilibre / Microstructures, diffusion and equilibrium diagrams - 4 ECTS
- EC : Physico-chimie des matériaux macromoléculaires / Physicochemistry of macromolecular materials - 3.00 ECTS
- EC : Physique microscopique du solide / Solid state physics - 6.00 ECTS
- EC : TP 1s - Matériaux - mesures - optoeélectronique / TP 1s - Materials - measurements - optoelectronics - 3.00 ECTS

UE : Science de l'Ingénieur / Engineering Science - 9 ECTS

- EC : Circuits électroniques - signaux systèmes / Electronic circuits - signals systems - 4.00 ECTS
- EC : Mathématiques / Maths - 4.00 ECTS
- EC : Techniques Numériques pour l'Ingénieur / Numerical Techniques for Engineers - 4.00 ECTS

UE : Humanités. Sports / Humanities, Sport - 7 ECTS

- EC : Sciences humaines et communications - 0.00 ECTS

SEMESTRE : 2eme semestre /2nd semester - 30 ECTS

UE : Projets collectifs : métier de l'ingénieur / Collective project : Material Engineering job's - 2 ECTS

- EC : Projets collectifs : Métiers de l'ingenieur matériaux /Collective project : Material engineer's job - 3.00 ECTS

UE : Science des Matériaux / Materials Science - 10 ECTS

- EC : Techniques de caractérisation structurale et introduction à la plasticité / Structural characterization techniques and introduction to plasticity - 4.00 ECTS
- EC : Materiaux semi-conducteurs / Semiconductors materials - 3.00 ECTS
- EC : Physico-chimie des matériaux mineraux / Physico-chemistry of mineral materials - 4.00 ECTS
- EC : TP - Capteurs et matériaux semiconducteurs / TP - Sensors and semiconductor materials - 2.00 ECTS
- EC : TP - Cristallographie - matériaux de structure / TP - Crystallography - structural materials - 2.00 ECTS

UE : Science de l'Ingénieur / Engineering Science - 12 ECTS

- EC : Transfert thermique et mécanique des fluides / Heat transfer and fluid mechanics - 4.00 ECTS
- EC : Probabilités Statistiques / Statistics and Probabilities - 4.00 ECTS
- EC : Mesures Capteurs / Measures, sensors - 3.00 ECTS
- EC : Ecoconception et ACV - Eco-design and LCA - 4.00 ECTS

EC : Mécanique des solides déformables / Deformable solid mechanics - 6.00 ECTS

ANNEE : 4ème année / 4th year - 60 ECTS

SEMESTRE : 1er semestre / 1st Semester - 30 ECTS

UE : Matériaux Semi Conducteurs / Semi conductors Materials - 9 ECTS

EC : Matériaux et dispositifs semiconducteurs / Semiconductor materials and devices - 4.00 ECTS

EC : Technologie des Matériaux et composants semi-conducteurs & MEMS / Semiconductor & MEMS Materials & Components Technology - 3.00 ECTS

EC : TP - matériaux et composants semi-conducteurs / TP - Semi-conductor materials and components - 4.00 ECTS

UE : Matériaux de Structure / Structural Materials - 16 ECTS

EC : Céramiques et Verres / Ceramics and Glass - 3.00 ECTS

EC : Comportement mécanique des matériaux / Mechanical behavior of materials - 6 ECTS

EC : Corrosion et durabilité des matériaux / Corrosion and durability of materials - 3.00 ECTS

EC : Métallurgie / Metallurgy - 6.00 ECTS

EC : TP - physico-chimie et mécanique des matériaux / TP - physico-chemistry and mechanics of materials - 4.00 ECTS

SEMESTRE : 2eme semestre /2nd semester - 30 ECTS

UE : Science de l'Ingénieur / Engineering Science - 7 ECTS

EC : Controle non destructif / Non Destructive Testing - 3.00 ECTS

EC : Matériaux Numériques / Digital Materials - 3.00 ECTS

EC : Eléments finis / Finite Elements - 4.00 ECTS

EC : Plans d'expériences / Experimental design - 1.00 ECTS

UE : Projets collectifs matériaux. stages - 9 ECTS

EC : Projet Personnel Professionnel - 0.00 ECTS

EC : Stage en entreprise / Industrial Internship - 6.00 ECTS

EC : Projet collectif matériaux - Accompagnement en management des équipes projet / Collective materials project - Management coaching for project teams - 3.00 ECTS

UE : Humanités. Sports / Humanities, Sport - 4 ECTS

EC : INSPIRE - Montage de projet responsable - 0.00 ECTS

UE : Science des Matériaux / Materials Science - 10 ECTS

EC : Matériaux Polymères : Propriétés mécaniques et viscoélasticité / Polymer materials: mechanical properties and viscoelasticity - 3.00 ECTS

EC : TP - Caractérisation de composants semi-conducteurs / Practical work - Characterization of semiconductor components - 1.00 ECTS

EC : TP - Elaboration et caractérisation de Matériaux Macromoléculaires / TP - Elaboration and characterization of Macromolecular Materials - 3.00 ECTS

EC : Composants Semiconducteurs/ Semiconductor components - 2.00 ECTS

EC : Matériaux composites / Composite materials - 2.00 ECTS

EC : Matériaux Polymères : Design macromoléculaire et physico-chimie / Polymer materials: macromolecular design and physical chemistry - 3.00 ECTS

ANNEE : 5ème année / 5th year - 60 ECTS

SEMESTRE : 1er semestre / 1st Semester - 30 ECTS

UE : Sciences de l'ingénieur / Engineer Science - 6 ECTS

- EC : Intelligence artificielle et apprentissage en Sciences de Matériaux / Artificial Intelligence and Learning in Materials Science - 4.00 ECTS
- EC : Matériaux pour l'Energie Materials for Energy - 4.00 ECTS
- EC : Conception de Matériaux pour un Futur Soutenable / Designing Materials for a Sustainable Future - 4.00 ECTS

UE : Science des Matériaux / Materials Science - 4 ECTS

- EC : Capteurs pour applications environnementales, biologiques et santé / Sensors for environmental, biological and health applications - 2.00 ECTS
- EC : Technologies émergentes de la nanoélectronique CMOS avancée / Emerging technologies in advanced CMOS nanoelectronics - 1.00 ECTS
- EC : Ingenierie Surface / Surface Engineering - 4.00 ECTS
- EC : Méthode numériques pour la Mécanique des Matériaux architecturés / Numerical Methods for the Mechanics of Architectural Materials - 2.00 ECTS
- EC : Durabilité Polymères / Polymer Durability - 2.00 ECTS
- EC : Matériaux photoniques / Photonic materials - 2.00 ECTS
- EC : Cours Option ECIU / Optionnal Lecture - ECTS
- EC : Procédés de mise en forme des matériaux métalliques,polymères et composites / Forming processes of metallic materials, composites and polymers - 4.00 ECTS
- EC : Matériaux pour la Santé / Materials for Health - 4.00 ECTS
- EC : Nanomatériaux polymères / Polymer nanomaterials - 2.00 ECTS
- EC : Design des Matériaux / Materials Design - 0.00 ECTS
- EC : Energie Photovoltaïque / Photovoltaic Energy - 2.00 ECTS

UE : Projets collectifs. PFE / Collective Projects , PFE - 17 ECTS

- EC : Projet de fin d'étude / End of study Project - 15.00 ECTS
- EC : Projet : physique et mécanique des matériaux inorganiques /Project: physics and mechanics of inorganic materials - 2.5 ECTS
- EC : Projet :Elaboration, mise en forme et caractérisation des materiaux polymères / Project :Development, shaping and characterization of polymers - 2.50 ECTS
- EC : Caractérisation-simulation des semiconducteurs et composants / Project: Characterization and simulation of semiconductors and components - 2.50 ECTS
- EC : Caractérisation et simulation des semiconducteurs et composants2 / Project: Characterization and simulation of semiconductors and components2 - 2.50 ECTS

SEMESTRE : 2eme semestre /2nd semester - 30 ECTS

- EC : Stage / Internship - 30.00 ECTS

# Introduction to materials science

## IDENTIFICATION

CODE : MT-3-S1-EC-INTRO
ECTS : 2.00

## HOURS

| | |
|---|---|
| Cours : | 26h |
| TD : | 2h |
| TP : | 10h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 38h |
| Travail personnel : | 0h |
| Total : | 38h |

## ASSESMENT METHOD

The evaluation will be carried out by means of a mini project

## TEACHING AIDS

Lectures slides

## TEACHING LANGUAGE

French

## CONTACT

MME CAZOTTES Sophie : sophie.cazottes@insa-lyon.fr

## AIMS

This course provides a general introduction to materials science.

The objectives at the end of the course are

- Definition of the different families of materials, their respective fields of application and their range of properties

- Definition of the structural properties of materials

- Definition of the functional properties of materials

- Presentation of the methods of shaping of materials

- Introduction of the link between microstructures and properties in the major classes of materials.

- Definition of the materials science engineering profession, and the major challenges to be faced in this field in the future (including recycling, resource management and materials for energy)

This EC MT-3-INTRO comes under the Teaching Unit MT-3-UE-SDM-S1 Science of Materials Semester 1 and contributes to:

School skills in science for engineers:
A1 - Analyze a real or virtual system (or problem) (level 1)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specificity (level 1)

Specialty-specific school skills:
C1 - Knowing and being able to establish the Structure-Property relationships of Materials A2 - name of the skill (level 1)
C2 - Identify and implement materials development methods (level 1)
C5 - Innovate and research in materials (level 1)
B2 - Work, learn, evolve independently (level 1)
B3 - Interact with others, work in a team (level 1)
B4 - Be creative, innovate, undertake (level 1)

By mobilizing the following skills:
A1 - Analyze a real or virtual system (or problem)
B2 - Work, learn, evolve independently
B3 - Interact with others, work in a team

By allowing the student to work on the following knowledge:
- Know the different families of materials, their respective fields of application and their ranges of properties
- Know the structural properties of materials
- Know the functional properties of materials
- Have basic notions on the methods of forming materials.
- Know the profession of engineer in materials sciences, and the major challenges to be met in this field in the future years (in particular: recycling, management of resources and materials for energy)

By allowing the student to work and be assessed on the following skills:
- be able to describe the most common properties of the main families of materials
- be able to describe the most common properties in a simple way
- be able to make the basic link between microstructures and properties in the main classes of materials.

## CONTENT

Job: Materials Engineer 1h30

A history of Material Science 3h

Basic knowledge of material properties
- Functional properties 1h30
- Structural properties 1h30

Definition of the families of materials, and their applications, and their properties. Link with their microstructure.
- Metallic materials 3h
- Polymeric materials 3h

- Ceramic materials 3h
- Semi-conductive materials 3h

Notions on elaboration processes
- for metallic materials 1h30
- for polymeric materials 1h30
- for semiconductor materials 1.5 hours

Challenges in materials science
- Resource management 1.5 hours
- Waste management, re-use, recyclability 1.5 hours
- Development of materials for energy 1h30

Introduction to researching scientific documents: 2h tutorial

Case study project: (groups of 6-8) 12 hours independent work

## BIBLIOGRAPHY


- Materials, Jean Paul Baïlon, Jean Marie Dorlot, Presses Internationales Polytechnique, 2000

- Materials Science and Engineering: An Introduction William D. Callister, David G. Rethwisch, Wiley, Jan 5, 2010


## PRE-REQUISITES

None

# Microstructures, diffusion and equilibrium diagrams

## IDENTIFICATION

CODE : MT-3-S1-EC-MICRODD
ECTS : 4

## HOURS

| | |
|---|---|
| Cours : | 22h |
| TD : | 18h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 40h |
| Travail personnel : | 0h |
| Total : | 40h |

## ASSESMENT METHOD

The evaluation will be carried out by a 2 hours 30 written exam, consisting of a part on cristallography and another on defects, diffusion and equilibrium diagrams

## TEACHING AIDS

Lecture slides

## TEACHING LANGUAGE

English

## CONTACT

MME CAZOTTES Sophie :
sophie.cazottes@insa-lyon.fr
MME JOLY POTTUZ :
lucile.joly-pottuz@insa-lyon.fr

## AIMS

The objectives at the end of the course are
- Description of the usual crystalline structures, reading and use of the international tables of crystallography
- Definition of point defects
- Presentation of the constituent elements of the microstructure (precipitates, grain boundaries, interfaces, grains)
- Introduction to atomic diffusion in solids
- Lecture and use of equilibrium diagrams for the prediction of equilibrium microstructures.

This EC SGM-3-MICRODD comes under the SGM-3-UE-SDM-S1 Science ofMaterials Semester 1 and contributes to:

School skills in science for engineers:
A1 - Analyze a real or virtual system (or problem) (level 1)
A5 - Processing data (level 2)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specificity (level 2)

Specialty-specific school skills:
C1 - Knowing and being able to establish the Structure-Property relationships of Materials (level 1)
C4 - Modeling and predicting the behavior of materials (level 1)

By mobilizing the following skills:
B2 - Work, learn, evolve independently

By allowing the student to work and be assessed on the following knowledge
- knowledge of the different crystallographic structures
- knowledge of the elements of symmetry in crystallographic structures
- knowledge of Fick's laws governing atomic diffusion in solids
- knowledge of the rules for reading binary and ternary equilibrium diagrams

By allowing the student to work and be assessed on the following skills
- know how to describe a crystal, how to describe a plane, a crystallographic direction
- how to read and use international crystallography tables
- be able to describe defects (point, two- and three-dimensional) in solids
- be able to calculate a solid diffusion coefficient, diffusion distances or equilibrium concentrations
- be able to read an equilibrium diagram, predict the microstructure of a binary or ternary system and calculate the corresponding phase fractions

## CONTENT

Basics of crystallography:

- simple cubic and hexagonal systems
- Miller indices
- pattern/lattice/crystal/symmetry definition
- Reciprocal and direct lattice

Point defects: vacancies, interstitial atoms, substitutional atoms
2D and 3D defects (grains/precipitates/grain boundaries..)

Solid state diffusion:

- First and second Fick's laws
- Calculation of diffusion distance

Binary and ternary equilibrium diagrams

## BIBLIOGRAPHY

[1] "Cristallographie " - D.SCHWARZENBACH, Presses Polytechniques et Universitaires Romandes 1993

[2] Caractérisation microstructurale des matériaux analyse par les rayonnements X et électronique de Claude Esnouf chez Presses polytechniques et universitaires romandes

[3] Des Matériaux, Jean Paul Baïlon, Jean Marie Dorlot, Presses Internationales Polytechnique, 2000

[4] Materials Science and Engineering: An Introduction William D. Callister, David G.Rethwisch, Wiley, 5 janv. 2010

## PRE-REQUISITES

Lecture : MT-3-S1-EC-INTRO

# Physical Chemistry of Macromolecular Materials

## IDENTIFICATION

CODE : MT-3-S1-EC-PCMMOL
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 20h |
| TD : | 14h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 34h |
| Travail personnel : | 0h |
| Total : | 34h |

## ASSESMENT METHOD

For the theoretical course, one written examination (3 hours) with course notes

## TEACHING AIDS

lecture notes

## TEACHING LANGUAGE

French

## CONTACT

M. FLEURY Etienne :
etienne.fleury@insa-lyon.fr

## AIMS

This module aims to give the student basic knowledge of:
- The chemical structure of organic molecules
- The chemical structure of industrial polymers
- The synthesis methods of the main families of industrial polymers
- The molar masses of polymers
- Molecular characteristics (conformations, configurations, crystalline morphologies)
- The physical characteristics of polymers (Tg, T', Tf, Tm transitions)
- The relationships between chemical structures and thermal properties.

This course falls under the MT-3-S1-UE-SDM Teaching Unit and contributes to:

School skills in engineering sciences:
A5 - Processing data

School skills specific to the speciality:
C1 - Know and be able to establish the Structure-Properties relationships of Materials (Level 2)
C2 - Identify and implement methods for developing materials (Level 1)
C4 - Model and predict the behaviour of materials (Level 1)

By mobilising the following skills:
A2 - Use a model of a real or virtual system
A4 - Design a system that meets specifications
A6 - Communicate a scientific analysis or approach with scenarios adapted to their speciality
B2 - Work, learn and develop independently

By allowing the student to work and be assessed on the following knowledge:
- understand and know how to apply simple nomenclature rules
- know the names, abbreviations, chemical formulae, Tg and possibly Tf of the following polymers: polyethylene, polypropylene, polystyrene, polyvinyl chloride, polyethylene terephthalate PET, polyamides, polyisoprene/polybutadiene, polydimethylsiloxane PDMS, polymethyl methacrylate, polycarbonate
- to know and understand the principle of differential scanning calorimetry
- to know the formulas for the average molar masses in number and mass, the average degrees of polymerisation in number and mass, and to understand their significance.
- to know the chemical reactions: polyesterification, polyamidation, alcohol/isocyanate polyaddition, free-radical polymerisation, and to understand their mechanisms.
- know the techniques for measuring crystallinity,
- know and be able to apply the formulas for radii of gyration

By allowing the student to work and be assessed on the following abilities:
- Be able to apply the Avrami Formula to process the crystallisation kinetics of a polymer
- Being able to establish links between the chemical structures of polymers and thermal properties (Tg and Tf)

## CONTENT

- Structure of organic molecules
- Physical characteristics of polymers. Configurations, conformations, morphologies, transitions Tg and Tm, kinetics of cristallization
- Synthesis of polymers : polycondensation and polyaddition, chain polymerization. Notion of thermosets.

## BIBLIOGRAPHY

[1] S.ROSEN Fondamental principales of polymeric materials Editions .Wiley

[2] G.ODIAN Principles of polymerization Editions Mc Graw-Hill

[3] J.L. HALARY, F. LAUPRETRE De la macromolécule au matériau polymères ed. Belin 2005

[4] S. ETIENNE, L. DAVID Introduction à la physique des polymères ed. Dunod 2002

# Microscopic solid state physics

## IDENTIFICATION

CODE : MT-3-S1-EC-PHYMIC
ECTS : 6.00

## HOURS

| | |
|---|---|
| Cours : | 30h |
| TD : | 18h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 48h |
| Travail personnel : | 0h |
| Total : | 48h |

## ASSESMENT METHOD

3h final exam

## TEACHING AIDS

Lecture slides on the Moodle platform

## TEACHING LANGUAGE

English

## CONTACT

M. MASENELLI Bruno : bruno.masenelli@insa-lyon.fr

M. FAVE Alain : alain.fave@insa-lyon.fr

## AIMS

Microscopic description of the phenomena ruling the macroscopic behavior of crystalline solids

This EC falls under the Teaching Unit MT-3-S1-UE-SDMand contributes to:

School skills in science for engineers:
A1- Analyze a real or virtual system (or problem) [level 2]
A2- Use a model of a real or virtual system [level 2]
A4- Design a system that meets specifications [level 2]
A6- Communicate an analysis or a scientific approach with scenarios adapted to their specialty [level 2]

Specialty-specific school skills:
C1 - Know and be able to establish the Structure-Property relationships of Materials [Level 2]
C4 - Modeling and predicting the behavior of materials [Level 1]

By mobilizing the following skills:
B2-Work, learn, evolve independently [level 3]

## CONTENT

- First level Statistics: binomial and Gaussian distribution. Kinetic theory of gases.

- Temperature and entropy, functions of partition, chemical potential, statistical ensembles. Maxwell model. Thermal and electronic diffusion and conduction

- Elements of Quantum Physics

- Energy equipartition theorem. Einstein model of solids. Specific heat of solids. Filling of energy bands

- Chemical bonds

- Dispersion relations of vibration and electronic waves in crystals. Band theory

- Physics of electrons and phonons in crystalline solids

- Physics of photons

- Solid state optics (effective medium approximation ; Lorentz description)

## BIBLIOGRAPHY

C. Coulon et S. Moreau, Physique statistique et thermodynamique, Dunod, 2000
F. Reif, Physique statistique, Berkeley : cours de physique, Armand Collin (1972)
S. Vauclair, Elements de Physique statistique, InterÉditions (1993)
C. Ngo, Physique statistique, Dunod (1995)
N. W. Ashcroft et N. D. Mermin, Physiques des Solides, EDP science (2002)
C. Kittel et J. Wiley, Physique de l¿état solide Dunod, 2019

## PRE-REQUISITES

General Physics course
Thermodynamic course
Point mechanics course
Physcial optics course

# materials optoelectronic measurements

## IDENTIFICATION

CODE : MT-3-S1-EC-TPMES
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 48h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 48h |
| Travail personnel : | 0h |
| Total : | 48h |

## ASSESMENT METHOD

- Reports (content, objectives, and delay as a function of the thematic), a sheet of results is asked for some practical works

- Oral evaluation (individual or per group) (conditions as a function of the thematic)

## TEACHING AIDS

- Lab work booklet available on MOODLE

- Printed versions on the benches

- Documents/books/technical instructions on the benches

## TEACHING LANGUAGE

French

## CONTACT

CHARLOT Aurelia :
aurelia.charlot@insa-lyon.fr

## AIMS

The objectives at the end of the course are :

- Discover the principles of signal acquisition techniques, and the elementary electronic components involved in this measurement.

- Discover polymer materials, identify and know the structural features of the widely diffused polymers, know their microstructure (amorphous and semi-crystalline), their thermal and thermomechanical properties in relation with their chemical structure, understand the crystallization of polymers and be familiar with the synthesis process by step polymerization

This EC falls under the teaching unit MT-3-UE-SDM-S1, Materials S1 and contributes to:

School skills in science for engineers:
A1 - Analyze a real or virtual system (or problem) (Level 1)
A2 - Use a model of a real or virtual system (Level 1)
A3 - Implement an experimental approach (Level 1)
A5 - Process data (Level 3)

School skills in humanity, documentation and physical and sports education:
B2 - Work, learn, evolve independently (Level 1)
B3 - Interact with others, work in a team (Level 1)

Specialty-specific school skills:
C1 - Knowing and being able to establish the Structure-Property relationships of Materials (Level 3)
C2 - Identify and implement materials development methods (Level 1)

By mobilizing the following skills:

A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty

## CONTENT

The practical works are organized in three thematic:

Modulus 1:
TP1: Atomic Force Microscopy
TP2: The photomultiplier
TP3: Cathodic pulverization

Modulus 2:
TP 4: Elastic modulus
TP5: Thermal conductivity
TP6: Differential thermal analysis
TP7: Dilatometry

Modulus 3:
TP 8: Crystallization kinetics of poly(ethylene oxide)
TP9: Thermomechanical properties of polymers
TP 10: Identification of polymers
TP 11: Synthesis of polyamide 11 by polycondensation

## BIBLIOGRAPHY

## PRE-REQUISITES

Basic knowledge in Physics and Chemistry

# Electronic circuits - signals-systems

## IDENTIFICATION

CODE : MT-3-S1-EC-ELESSY
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 24h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 24h |
| Travail personnel : | 0h |
| Total : | 24h |

## ASSESMENT METHOD

End of semester exam, duration 3h

## TEACHING AIDS

## TEACHING LANGUAGE

French
English

## CONTACT

M. MILITARU Liviu :
liviu.militaru@insa-lyon.fr

## AIMS

The objectives at the end of the course are

To provide the student with the basic knowledge to understand the operation of a data acquisition and processing chain, more particularly:

- The operation of linear systems

- The main amplifier assemblies using bipolar transistors and operational amplifiers,

- Passive or active analog filters

- Analog/digital conversion

- The representation of analog and digital signals in the frequency domain.

ThisEC MT-3-S1-EC-ELESSY falls under the Teaching Unit MT-3-S1-UE-SDI and contributes to:

School skills in sciences for the engineer:
A1 - Analyze a real or virtual system (or problem) (Level 1)
A2 - Use a model of a real or virtual system (Level 1)
A3 - Implement a scientific approach (Level 1)

School skills in humanity, documentation and physical and sports education:
B2 - Work, learn, evolve independently (Level 1)

By mobilizing the following skills:
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty
B1 - Self-evaluate one's own performance

## CONTENT

I. Linear systems
Particular responses of a scalar system
Operational calculation: Laplace transform
Equation of a linear scalar system
Performance of a linear system

II. Linear amplifier circuits
Bipolar transistor amplifiers
Operational amplifiers (AOP)
III. Analog signals

Fourier transforms
Passive and active filters

IV. Digital signals
Sampling
Quantization
Spectral representation of discrete signals

The student works and is evaluated on the following knowledge and abilities:

- know the representation of Bode diagrams of basic analog filters,

- know the hybrid parameters and the small signal models of the bipolar transistor,

- know the basic electronic functions of operational amplifiers

- know how to represent the frequency spectrum of the various analog and digital signals.

- be able to analyze the operation of an analog data acquisition system

- be able to understand and analyze basic linear amplifier circuits integrating bipolar transistors or operational amplifiers: determine their small signal equivalent diagrams, deduce their properties (gain)

By allowing the student to work and be assessed on the following abilities:

- be able to analyze the operation of a data acquisition system analog
- be able to analyze a linear automatic system: determine the diagram functional, study its properties,

## BIBLIOGRAPHY

[1] F. Manneville, J. Esquieu, Electronique : théorie du signal et composants, Ed.Dunod 1997

[2] F.Cottet, Traitement des signaux et acquisition de données , Ed. Dunod 2002

[3] Y. Granjon, Exercices et problèmes d'électronique, Ed. Dunod 2010

[4] L. Barrandon, D. Réant, K.A. Tehrani, Maxi fiches électronique, Ed. Dunod 2010.

[5] F. de Coulon, Théorie et traitement des signaux, Ed. PPUR 2000(Traité d'électricité, vol. VI)

## PRE-REQUISITES

Basic knowledge of electrical circuits and good level of mathematics (linear differential equations, Laplace and Fourier transforms).

# Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

## Mathematics

### IDENTIFICATION

CODE : MT-3-S1-EC-MATH
ECTS : 4.00

### HOURS

| | |
|---|---|
| Cours : | 22h |
| TD : | 24h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 46h |
| Travail personnel : | 0h |
| Total : | 46h |

### ASSESMENT METHOD

One mid-semester written test ( 1 hour) without document. One written examination (3 hours) at the end of the semester with only a personal two page formula reminder.

### TEACHING AIDS

- 1 polycop

- On line site on Moodle

### TEACHING LANGUAGE

French

### CONTACT

MME STEPHAN Pascale :
pascale.stephan@insa-lyon.fr

### AIMS

Provide mathematical tools adapted to specialised teaching

This EC MT-3-S1-EC-MATH comes under the MT-3-S1-UE-SDI Teaching Unit and contributes to:

School skills in engineering sciences:

A1 - Analyse a real or virtual system (or problem) (Level 1)
A2 - Use a model of a real or virtual system (Level 2)
A5 - Process data (Level 1)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their speciality (Level 2)

By mobilising the following skills:
B2 - Work, learn and develop independently

by allowing the student to work and be assessed on the following knowledge and skills:
- understanding the concept of convergence of a generalised integral;
- knowing some Eulerian functions and their properties, and being able to identify and use them in problem solving;
- knowing the different properties of the Laplace transform and its application to operational calculus;
- understand the notion of approximation of a periodic function by a trigonometric polynomial, and know the different properties of Fourier series;
- know the properties of the Fourier transform and the inverse transform
- understand the notion of distribution and its use in the modelling of physical phenomena

By allowing the student to work and be assessed on the following skills:
- be able to study the convergence of a generalised integral, and calculate its value;
- be able to calculate Laplace transforms of functions or their originals;
- be able to calculate Fourier series of periodic functions
- be able to use the Laplace and Fourier transforms as well as the Fourier series in solving problems arising from concrete situations and to interpret the results obtained;

### CONTENT

- Special functions : gamma, beta and « error function ».
- LAPLACE transforms and applications.
- FOURIER transforms and applications.
- FOURIER series and applications.
- L2 space of functions
- Orthogonal polynomials ( Hermite, Lagrange, Laguerre et Tchebicheff)

### BIBLIOGRAPHY

[1] Mathematical techniques. JORDAN et SMITH. Oxford university press.
[2] Séries de Fourier. Transformation de Laplace. BENICHOU Paul. Ellipses.

### PRE-REQUISITES

Knowledge of the 1st-Cycle INSA program of mathematics

# Numerical Techniques for Engineers

## IDENTIFICATION

CODE : MT-3-S1-EC-OUTINF
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 2h |
| TD : | 20h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 22h |
| Travail personnel : | 0h |
| Total : | 22h |

## ASSESMENT METHOD

2-hour supervised homework on computer

## TEACHING AIDS

- Free-access computer room with 45 workstations
- Courses/Tutorial work available on the Moodle digital learning platform

## TEACHING LANGUAGE

French

## CONTACT

M. MANDORLO Fabien :
fabien.mandorlo@insa-lyon.fr
M. MORTHOMAS Julien :
julien.morthomas@insa-lyon.fr

## AIMS

Engineers need to master scientific numerical tools. Whether for simple office use, for the development of communication tools and collective interfaces, or for more robust numerical calculations in the field of materials.

In this first year of the department, the aim of the Numerical Techniques for Engineers course is to teach students how to use simple numerical tools and programming tools such as Excel, Visual Basic and Python to solve materials science problems. They will learn how to apply a numerical solution approach to a materials physics problem: starting from hypotheses, writing an algorithm, and translating it into code in the appropriate language, and analyzing and representing the results. The tutorials will focus on simple numerical calculation algorithms such as least squares, Newton's method, gradient descent, and Fourier transform.

This course is part of the "Socle Commun Numérique" (Common Digital Core) that all INSA-Lyon engineering students must have covered during their training.

This EC SGM-3-S1-OUTINF falls under the Teaching Unit SGM-3-UE-SDI-S1 Engineering Science Semester 1 and contributes to:

School skills in science for engineers:
A1 - Analyze a real or virtual system (or problem)
A2 - Use a model of a real or virtual system
A5 - Processing data

Specialty-specific school skills:
C1-Know and be able to establish the Structure-Property relationships of Materials
C4-Modeling and predicting the behavior of materials

By mobilizing the following skills:
B2-Work, learn, evolve independently

## CONTENT

This course consists of ten two-hour tutorial sessions.
Part 1: Introduction to EXCEL (reminder)
- Working with cells and worksheets
- Calculating in EXCEL: direct calculation, functions
- Graphical representation
- Solver

Part 2: Introduction to VBA
- VBA environment
- Creating macros: recorder, modules, and procedures via the editor
- VBA programming: cell selection and values, variables, control structures, functions
- Interactive windows: dialog boxes, events and Userforms

Part 3: Python
- Numerical calculation: method of least squares, Newton's method, gradient descent, Fourier transform on material science examples.
- Graphics

## BIBLIOGRAPHY

Excel et VBA, M. Bidault, Le Programmeur - édition Pearson.

Matlab - Mathworks, http://fr.mathworks.com/help/matlab/index.html

## PRE-REQUISITES

Basic knowledge of Excel and Python programming.

# Humanities and communications

## IDENTIFICATION

CODE : MT-3-S1-EC-SCHCOM
ECTS : 0.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 33h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 33h |
| Travail personnel : | 0h |
| Total : | 33h |

## ASSESMENT METHOD

After a literature search, each group defines a correct problematics of its working theme and gives one hour conference which has to be creative (using theatrical devices, audiovisual resources). Each conference is followed by a debate with the other students.

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

MME LECLERE Julie :
julie.leclere@insa-lyon.fr

## AIMS

The aim of this course is to give students an introduction to human sciences. Groups of five students have to give a conference on a question which is relevant to human sciences. This conference has to be creative.

## CONTENT

This course gives a short overview of the history of human sciences from the eighteenth century towards nowaday. It also emphasizes the originality of human sciences which try to give critical interpretations of the human social and cultural productions.
After this short introduction, groups of five students have to choose a theme which is relevant to human sciences in order to give a creative conference. They are helped by their professor to define their working theme.
After a literature search, each group defines a correct problematics of its working theme and gives one hour conference which has to be creative (using theatrical devices, audiovisual resources)

Each conference is followed by a debate with the other students.

## BIBLIOGRAPHY

[1] R Debray, Cours de Médiologie générale, Paris, Gallimard, 2001

[2] S Mesure, Dictionnaire des sciences humaines, Paris, PUF, 2006

[3] E Morin, Introduction à la pensée complexe, Paris, ESF Editeur, 1992

[4] L Sfez, Critique de la communication, Paris, Seuil, 1992

## PRE-REQUISITES

Prerequisite : Courses « Sciences, cultures and societies » given to the undergraduate students of the INSA of LYON

Skills : communication with specialists and non-spécialists, cultural opening, creativity

Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Group projects : engineering professions

## IDENTIFICATION

CODE : MT-3-S2-EC-PCOMIM
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 25h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 25h |
| Travail personnel : | 0h |
| Total : | 25h |

## ASSESMENT METHOD

Written report similar to a technical article, for the group. Oral presentation

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. MASENELLI Bruno :
bruno.masenelli@insa-lyon.fr

MME JOLY POTTUZ :
lucile.joly-pottuz@insa-lyon.fr

## AIMS

initiation to management, contacts with different firms, familiarization to the engineer profession.
The aim is to lead the students think about the different tasks and roles of engineers having a background in material sciences. They should try to answer question such as : where is the maximum demand, what additional training they could need, how is the competition with engineers having different basic training like physics, mechanics, chemistry, etc.

## CONTENT

Each domain like « transportation » or « sport equipment » corresponds to a large number of steps or actors for a given object, as for instance, designing, rough materials providers, compounding, distribution and selling etc.
The work must be done by a group of 6 or 7 students (with a total of 12 groups). They have to organise by themselves, their time schedule and their contact between each others and their professors, and the most efficient method to obtain information from the company they have previously selected.

## BIBLIOGRAPHY

## PRE-REQUISITES

Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Characterization Methods and Plasticity

## IDENTIFICATION

CODE : MT-3-S2-EC-CARPLAS
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 22h |
| TD : | 18h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 40h |
| Travail personnel : | 0h |
| Total : | 40h |

## ASSESMENT METHOD

The evaluation will be carried out by a 2h30 written exam, consisting of a part on plasticity and another on microstructural characterisation

## TEACHING AIDS

Lecture slides

## TEACHING LANGUAGE

French
English

## CONTACT

MME JOLY POTTUZ Lucile : lucile.joly-pottuz@insa-lyon.fr

MME CAZOTTES Sophie : sophie.cazottes@insa-lyon.fr

## AIMS

The objectives at the end of the course are

- Description of the usual material characterization techniques (electron microscopy, X-ray diffraction, X-ray tomography)

- Description of dislocations, their properties

- Introduction to crystal plasticity

This EC SGM-3-CARPLAS falls under the Teaching Unit SGM-3-UE-SDM-S2 Science of Semester 2 materials and contributes to:

School skills in science for engineers:
A1 - Analyze a real or virtual system (or problem) (level 1)
A5 - Processing data (level 2)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specificity (level 2)

Specialty-specific school skills:
C1 - Knowing and being able to establish the Structure-Property relationships of Materials (level 1)
C4 - Modeling and predicting the behavior of materials (level 1)

By mobilizing the following skills:
B2 - Work, learn, evolve independently

By allowing the student to work and be assessed on the following knowledge:
- Know the limits and accuracy/resolution of each method
- Know the fundamental principles of the characterization methods covered in the course (SEM, MET, DRX, EBSD, in particular)
- Know the theory of dislocations (definition, interaction, notion of sliding, interactions between dislocations)
- Know the link between macroscopic stresses, such as macroscopic deformation, and forces applied to dislocations

By allowing the student to work and be assessed on the following skills:
- Know how to describe the operating principles of the usual characterization methods in materials
- Know how to interpret the results from microstructural characterization
- Know how to describe the associated microstructures.
- Know how to calculate the forces applied to dislocations and make the link with macroscopic stresses, as well as with macroscopic deformation
- Knowing how to use visualization/processing software for microstructural characterization data such as Aztec, Atex, Carine.

## CONTENT

1. Characterisation techniques
Diffraction basics
form factor ...
DRX
MEB - EDX - MET
EBSD + stereo projection
Surface analysis

2. Introduction to Plasticity
Definition of dislocations
Dislocation interactions
Dislocation sliding
Forces applied to dislocations
Sources of dislocations

## BIBLIOGRAPHY

[1] "Crystallography" - D.SCHWARZENBACH, Presses Polytechniques et Universitaires Romandes 1993

[2] Microstructural characterization of materials analysis by X-rays and electronics by Claude Esnouf at Presses polytechniques et universitaire romandes

[3] Materials, Jean Paul Baïlon, Jean Marie Dorlot, Presses Internationales

Polytechnique, 2000

[4] Materials Science and Engineering: An Introduction William D. Callister, David G. Rethwisch, Wiley, Jan. 5, 2010

## PRE-REQUISITES

Lecture : MT-3-INTRO

Lecture MT-3-MICRODD

# Semiconductor materials

## IDENTIFICATION

CODE : MT-3-S2-EC-MATSC
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 16h |
| TD : | 10h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 26h |
| Travail personnel : | 0h |
| Total : | 26h |

## ASSESMENT METHOD

Written examination of 3h00 with lecture notes

## TEACHING AIDS

Lecture notes on Moodle with some extra-documents

## TEACHING LANGUAGE

French
English

## CONTACT

M. MASENELLI Bruno :
bruno.masenelli@insa-lyon.fr

## AIMS

Basic knowledge of the physical properties of semiconductor materials to address subsequent device courses

This EC falls under the MT-3-UE-SDM S2 Materials S2 Teaching Unit and contributes to:

School skills in science for engineering:
A1 - Analyze a real or virtual system (or problem) (Level 1)
A4 - Design a system meeting specifications (Level 1)

School skills specific to the specialty:
C1 - Know and be able to establish the Structures-Properties relationships of Materials (Level 1)
C3 - Apply materials (Level 3)
C4 - Model and predict the behavior of materials (Level 2)

By mobilizing the following skills:
B2 - Work, learn, evolve independently
C2 - Identify and implement materials development methods
C5 - Innovate and research materials

By allowing the student to work and be evaluated on the following knowledge:

- know and understand the energy band diagrams characteristic of semiconductors

- know the concept of doping and know how to calculate doping rates for common dopants

- know how to apply the continuity equation to describe the evolution of simple non-equilibrium systems

- know the functioning of the PN junction (formation of the depletion zone) at equilibrium and under polarization (rectifying behavior)

## CONTENT

Program:
- General introduction of semiconductor materials
- Band structures , effective masses
- Transport properties, current in semiconductors
- Semiconductors out of equilibrium, recombination and generation mechanism, equation of continuity
- PN junction at equilibrium, biased PN junction, current expression

## BIBLIOGRAPHY

Bibliography
- ¿semiconductors device physics and technology¿, S.M. Sze, J. Wiley & Sons (1985)
- ¿composants à semiconducteurs: de la physique du solide anx transistors¿, O. Bonnaud ed. Ellipses (2007)
- « physique des semiconducteurs », B. Sapoval, C. Hermann ed. Ellipses (1990)
- « physique et technologie des semiconducteurs », F. Levy- PPUR (1995)
- « physique des semiconducteurs et composants électroniques », H. Mathiey ; ed. Dunnod (2009)

## PRE-REQUISITES

Prior knowledge
Basics of solid state physics, crystallography

# Physical Chemistry of Minerals Materials

## IDENTIFICATION

CODE : MT-3-S2-EC-PCMMIN
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 18h |
| TD : | 12h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 30h |
| Travail personnel : | 0h |
| Total : | 30h |

## ASSESMENT METHOD

One written examination (1,5 hours) + one oral seminar (20 mn)

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. NORMAND Bernard :
bernard.normand@insa-lyon.fr

## AIMS

Basic knowledge of physicochemistry to understand the structure of mineral materials, their properties, their means of characterization and their production. In addition, emphasis will be placed on extractive metallurgy to revisit the thermodynamic and kinetic concepts necessary for Materials Science and Engineering.

This EC falls under the Teaching Unit MT-3-UE-SDM-S2 Materials S2 and contributes to:

School skills in science for engineering:
A1 - Analyze a real or virtual system (or problem) (Level 1)
A2 - Use a model of a real or virtual system (Level 1)
A5 - Process data (Level 1)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty (Level 2)

School skills in humanity, documentation and physical and sports education:
B2 - Work, learn, evolve independently (Level 2)
B3 - Interact with others, work in a team (Level 1)

School skills specific to the specialty:
C1 - Know and be able to establish the Structures-Properties relationships of Materials (Level 1)
C2 - Identify and implement materials development methods (Level 2)
C4 - Model and predict the behavior of materials (Level 1)

By mobilizing the following skills:
A3 - Implement an experimental approach
B4 - Show creativity, innovate, undertake
C3 - Apply the materials

By allowing the student to work and be evaluated on the following knowledge:

- Master the fundamentals of atomistics, from elementary particles to bonds,

- Have basic notions of the chemistry of solutions

- Master the fundamentals of thermodynamics, equilibrium diagrams

- Have the basic concept that links electrochemistry and thermodynamics: potential

## CONTENT

Matership of general inorganic chemistry concepts

- Interaction between solid minerals (and metals) and gases : Ellingham diagrams thermodynamic and Kinetic, oxidation.

- Interaction between solid minerals (and metals) and solutions : solubility electrochemistry, solvatation ...

- Elaboration process : thermodynamic basis and industrial processes.

## BIBLIOGRAPHY

[1] Ph. A. JAVET, P. LERCH and E. PLATTNER : Introduction à la chimie pour Ingénieurs,
Presses Polytechniques Romandes (1987)

[2] C. DUBOC, L. LEMERLE, Y. LE ROUX, J. TALBOT, Chimie, tomes 1 et 2 Armand Colin (1987)

[3] M. BERNARD : Cours de Chimie Minérale, Dunod (1990)

# Practical Sensors

## IDENTIFICATION

CODE : MT-3-S2-EC-TPCAP
ECTS : 2.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 21h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 21h |
| Travail personnel : | 0h |
| Total : | 21h |

## ASSESMENT METHOD

No exam. Written reports for each sessions are required to give marks. All the marks have the same weight to determine the end-of-term final mark.

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. MANDORLO Fabien :
fabien.mandorlo@insa-lyon.fr

## AIMS

Deepen knowledge of how the main types of
sensors used in physical measurements work. OBJECTIVES.

This course falls under the MT-3-S2-UE-SDM, Materials S2 teaching unit and contributes to:

School skills in engineering sciences:
A1 - Analyse a real or virtual system (or problem) (Level 1)
A2 - Use a model of a real or virtual system (Level 2)
A3 - Implement an experimental approach (Level 1)
A4 - Design a system that meets specifications (Level 1)
A5 - Process data (Level 3)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their speciality (Level 1)

Skills in humanities, documentation and physical education and sports:
B3 - Interact with others, work in a team (Level 1)
B4 - Demonstrate creativity, innovate, be enterprising (Level 1)
B6 - Situate oneself, work and develop in a company or a socio-productive organisation (Level 1)

School-specific skills for the specialism:
C1 - Know and be able to establish the structure-property relationships of materials (Level 1)
C3 - Apply materials (Level 1)
C4 - Modelling and predicting the behaviour of materials (Level 2)

By mobilising the following skills:
C5 - Innovating and researching materials

## CONTENT

SEMI-CONDUCTORS
- Schottky diodes and PN junctions
- Characterisation of semiconductor materials
SENSORS
- Chemical sensors (ISFET),
- Thermal sensors,
- Magnetic sensors,
- Mechanic sensor,
- Vibration sensors.

## BIBLIOGRAPHY

## PRE-REQUISITES

Basic Physics, optical and electrical measurements

# Practical Caracterisation

## IDENTIFICATION

CODE : MT-3-S2-EC-TPCRIST
ECTS : 2.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 21h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 21h |
| Travail personnel : | 0h |
| Total : | 21h |

## ASSESMENT METHOD

Evaluation by CR and by Individual Oral of 20 minutes

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

MME JOLY POTTUZ : lucile.joly-pottuz@insa-lyon.fr

## AIMS

Cristallography

Experimental and pratical illustrations of the course « characterization for materials

- Phase diagram analysis in relation with material microstructure

- Materials physical properties measurements in relation with their structure and composition

## CONTENT

Measurement of the diffraction pattern of a biphasic powder :

Ray powder diffraction : quantitative analysis

- EBSD : application to métals

- Electron diffraction : Analysis of diffraction pattern and understanding of the use of the reciprocal lattice

- Scanning electron microscope imaging

- Metallographic study of Fe-C diagram

- Thermal conductivity

- Metal resistivity

## BIBLIOGRAPHY

[1] Ray diffraction in crystals, imperfect crystals and amorphous bodies « GUINIER - ISBN 0486680118 - DOVER Publications 1994

[2] International tables for crystallography, Vol A, Theo Hahn Ed. Kluwer Academic Publishers 1989

[3] C. Kittel, Physique de l'état solide, 7e éd., Paris, Dunod, 1998, 610 p., ISBN : 2-10-003267-4

[4] Philibert J., Métallurgie, du minerai au matériau : cours et exercices corrigés, Jean Philibert, Alain Vignes, Yves Bréchet et al. Eds., 2e éd., Paris, Dunod, 2002, 1177 p., ISBN : 2-10-006313-8

## PRE-REQUISITES

- Crystallography

- Physics of interaction of X rays and electrons with matter

- Solid state

- Phase diagrams

# Heat transfer and fluid mechanics

## IDENTIFICATION

CODE : MT-3-S2-EC-TTMFLU
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 24h |
| TD : | 12h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 36h |
| Travail personnel : | 0h |
| Total : | 36h |

## ASSESMENT METHOD

For the theoretical course : one written examination (3 hours).

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

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M. KLEBER Xavier : xavier.kleber@insa-lyon.fr

## AIMS

Fundamentals of heat transfer.
Elementary study of fluids mechanics

## CONTENT

Heat Transfer :
- Different types of heat transfer mechanisms
- Heat balance equation
- Resolution of the heat equation in some specific examples

Fluid Mechanics :
- Fundamental of fluids mechanics. Hydrostatics. Archimede theorem.
- Dynamics of fluids. The equation of continuity.
- Dynamics of Ideal Fluids. Euler¿s equation. Bernoulli¿s theorem. Euler¿s theorem.
- Dynamics of viscous fluids. Navier-Stokes equation. The Reynolds number.

## BIBLIOGRAPHY

[1] Mécanique expérimentale des fluides. R. Comolet. Masson.

## PRE-REQUISITES

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

**Ingénieur, spécialité matériaux**

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Probability -Statistics

## IDENTIFICATION

CODE : MT-3-S2-EC-PROBA
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 24h |
| TD : | 24h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 48h |
| Travail personnel : | 0h |
| Total : | 48h |

## ASSESMENT METHOD

One mid-semester written test ( 1 hour) without document. One written examination (3 hours) at the end of the semester with only a personal two page formula reminder.

## TEACHING AIDS

- 1 polycop

- On line site on Moodle

## TEACHING LANGUAGE

French

## CONTACT

MME STEPHAN Pascale :
pascale.stephan@insa-lyon.fr

## AIMS

Basic knowledge of statistics
Application : Industrial controls (receiving- SPC)
Quality of measuring instruments

## CONTENT

- Statistical description
- Probability
- Random variable and random vector.
- Special probability distributions.
- Sampling distributions.
- Estimation.
- Parametric tests.
- Applications: fiability and industrial controls.
- Computer seminar on EXCEL software.

## BIBLIOGRAPHY

[1] Probabilités, analyse des données et statistiques. SAPORTA Gilbert. Technip.
[2] Initiation aux probabilités. Sheldon ROSS.Presses polytechniques et universitaires romandes.

## PRE-REQUISITES

Knowledge of the 1st-cycle INSA program of mathematics

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

**Ingénieur, spécialité matériaux**

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Measurement Sensors

## IDENTIFICATION

CODE : MT-3-S2-EC-MESCAP
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 10h |
| TD : | 20h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 30h |
| Travail personnel : | 0h |
| Total : | 30h |

## ASSESMENT METHOD

Notation of the oral presentation and written report of a subject previously choosen for a group of two students

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. Malhaire Christophe :
christophe.malhaire@insa-lyon.fr

## AIMS

The aim of this course is to train students in the field of sensors used today in many activities, particularly automation. The notions of choosing a sensor are discussed. This is the opportunity for them to give a one-hour oral presentation on a previously chosen subject that fascinates them.

This EC falls under the Teaching Unit MT-3-S2-UE-SDI and contributes to:

School skills in science for engineering:
A1 - Analyze a real or virtual system (or problem) (Level 1)
A2 - Use a model of a real or virtual system (Level 2)
A4 - Design a system meeting specifications (Level 1)
A5 - Process data (Level 1)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty (Level 2)

School skills specific to the specialty:
C1 - Know and be able to establish the Structures-Properties relationships of Materials (Level 1)
C3 - Apply materials (Level 2)

By mobilizing the following skills:
A3 - Implement an experimental approach
B2 - Work, learn, evolve independently
C2 - Identify and implement materials development methods
C4 - Model and predict the behavior of materials

By allowing the student to work and be evaluated on knowledge following:

- know the different modes of transduction of physical, chemical, mechanical quantities,

- know how to identify the electronic circuits associated with the conditioning of the sensor,

By allowing the student to work and be evaluated on the following abilities:

- Being able to choose the appropriate sensor depending on the application,

- Be able to design a measurement chain based on specifications,

- Be able to present a sensor problem.

## CONTENT

- Principles of transducers : general characteristics, choice of a transducer
- transducers for mechanical physical and technical measurements
- The subjects are relative to ranges such as :
- sensors and transport
- sensors and telecommunication
- sencors and audio-video technology
- microbiochemical sensors in biologyand Medicine
- sensors and environment (pollution, analysis)
- sensors and energy (plutocell)
- sensors and home automation
- sensors and signal conditioning equipment (bridge method)

## BIBLIOGRAPHY

[1] G.ASCH and A1 : les capteurs en instrumentation industrielle Ed.dunod (1991)

[2] L'Audiovisuel J.J Matras que sais-je ? n°1575

[3] Intelligent sensor technology Wiley (1992)

[4] Guide pratique des capteurs .Ichinose Ed . MASSON (1993)

[5] Microengineering in Biology and Medicine A.Dittmar, Proceedings ESEM (1995)

[6] Telecommunications optiques, P.Lecuy Ed. HERMES (1992)

[7] Capteur à fiche optique P.BESNIER Ministère de l'Industrie et du Commerce Extérieur
ISSN : 0767-5380 Paris (1995)

## PRE-REQUISITES

**Ingénieur, spécialité matériaux**

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Eco design - LCA

## IDENTIFICATION

CODE : MT-3-S2-EC-ECOACV
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 10h |
| TD : | 12h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 22h |
| Travail personnel : | 0h |
| Total : | 22h |

## ASSESMENT METHOD

Individual assessment by MCQ (2 MCQs of 15 min)
Collective assessment of the case study / LCA: production of a summary sheet or poster and oral presentation

## TEACHING AIDS

Syllabus (lecture slides)
Possible thematic documents for in-depth studies
Softwares (CES Edupack, Simapro)

## TEACHING LANGUAGE

French

## CONTACT

MME BARRES Claire :
claire.barres@insa-lyon.fr

MME MASSARDIER-NAGEOTTE Valerie :
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## AIMS

The objectives at the end of the course are :

- to understand the challenges of eco-design in the field of materials: regulatory, economic, industrial and societal.

- to provide an initial understanding of the methods and tools involved, by teaching how to take environmental aspects into account in specifications

- to learn how to quantify the impacts of the choices made using LCA

- to develop a critical approach in the analysis of LCA results

This EC SGM-3-S2-ECOACV comes under the Teaching Unit SGM-3-UE-SDI-S2 and contributes to :

School skills in engineering sciences :

A1-Analyze a real or virtual system (or problem) Level 2
A2-Exploit a model of a real or virtual system Level 2
A4-Design a system to meet specifications Level 2
A6-Communicate a scientific analysis or approach, using situations adapted to their specificity Level 2

Specialty-specific school skills

C1-CKnow and be able to establish the relationships between structures and properties of materials Level 1
C2-Identify and apply methods of materials processing Level 2
C3-Put materials into practice Level 1
C5-Innovate and research materials Level 1

By mobilizing the following skills:

B2-Work, learn and develop independently
B3-Interact with others, work as part of a team
B4-Create, innovate, undertake
B5-Act responsibly in a complex world

## CONTENT

- Issues of eco-design of materials (6h CM):
General context and industrial vision.
Notion of specifications and consideration of environmental issues.
Scientific approach focused on materials.

- In-depth study of specific topics (6h TD) :
Regulations, REACH directives
Choice of materials (CES Edupack): multi-criteria approach

- LCA of materials (4h CM):
Introduction to the manufacture of materials
Introduction to the Eco Invent database
Principles of LCA applied to materials

- Case study (6h TD)
Carrying out an LCA using professional software

## BIBLIOGRAPHY

[1] ISO, I. (2006). 14040. Environmental management, Life Cycle Assessment, Principles And Framework.

[2] ISO, I. (2006). 14044: Environmental Management, Life Cycle Assessment, Requirements and Guidelines.

[3] Role and responsibilities of analysts in communicating Life Cycle Assessment results to decision makers: a case study in building sector. Proceedings of the SETAC Europe Annual Meeting 2014, Basel, Marion Sie, Jerôme Payet, 2014

[4] ¿Recyclable and bio-based materials open up new prospects for polymers : Scientific and social aspects¿ dans le livre « Environmental impact of polymers ». Valérie Massardier, Ed. Th Hamaide, R. Deterre, JF Feller, Wiley, DOI: 10.1002/9781118827116.ch12 Lavoisier-Hermès, 2014.

[5] A review to guide eco-design of reactive polymer based materials, Emma Delamarche, Valérie Massardier, Remy Bayard, and Edson Dos, dans Reactive and Functional Polymers Volume Three, Advanced materials, Editors: Gutierrez, Tomy (Ed.), Octobre 2020. https://www.springer.com/gp/book/9783030504564#aboutBook

## PRE-REQUISITES

Basic knowledge in materials
Basic knowledge in design

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

**Ingénieur, spécialité matériaux**

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Mechanics of materials

## IDENTIFICATION

CODE : MT-3-S2-EC-MECA
ECTS : 6.00

## HOURS

| | |
|---|---|
| Cours : | 16h |
| TD : | 18h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 34h |
| Travail personnel : | 0h |
| Total : | 34h |

## ASSESMENT METHOD

Paper exam

## TEACHING AIDS

Polycopies

## TEACHING LANGUAGE

English

## CONTACT

M. OLAGNON Christian :
christian.olagnon@insa-lyon.fr

## AIMS

Present the basic notions of the general theory of mechanics of elastic deformable solids necessary to solve classical problems of linear elasticity.

This EC falls under the teaching unit MT-3-UE-SDI-S2 Engineering Science S2 and contributes to:

School skills in science for engineering:
A1 - Analyze a real or virtual system (or problem) (Level 2)
A2 - Use a model of a real or virtual system (Level 2)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty (Level 2)

School skills specific to the specialty:
C1 - Know and be able to establish the Structures-Properties relationships of Materials (Level 1)
C4 - Model and predict the behavior of materials (Level 1)

By mobilizing the following skills:
A5 - Process data

By allowing the student to work and be assessed on the following knowledge and abilities:
- Know the concept of constraint vector.
- Know the concept of stress tensor.
- Know Hooke's law in isotropic solids.
- Know the general equations of the theory of elasticity, in particular the limit equations and indefinite equilibrium.
- Know the concept of strain energy.
- Know the method for solving elasticity problems.

By allowing the student to work and be evaluated on the following abilities:
- Be able to apply the theory of elasticity to simple examples: traction, compression, torsion.
- Be able to calculate a stress field on materials mounted in series and/or parallel.
- Be able to calculate the main directions of a mechanical tensor using a matrix or graphical method (Mohr's tricircle).
- Be able to analyze a stress or strain field solution

## CONTENT

- Introduction :
- Stress vector
- Stress tensor : Definition, principal values , Mohr circle
- Strain tensor : Definitions, pure deformation, distorsion
- Stress - strain relations, Elastic tensor : Hooke's law, application to isotropic bodies.
- General equation of elasticity.
- strain energy and rupture criteria

## BIBLIOGRAPHY

[1] TIMOSHENKO S. and COODIER J.N "Theory of Elasticity" Mc Graw-Hill 3rd Ed. (1970)

[2] HENRY J.P et PARSY F. "Cours d'élasticité" Dunod Université, Bordas Paris (1982)

[3] ROYIS, "Mécanique des Milieux Continus", cours, exercices et problèmes", ENTPE Collection, PUL (2005)

## PRE-REQUISITES

# Semiconductor materials and devices

## IDENTIFICATION

CODE : MT-4-S1-EC-MADISC
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 18h |
| TD : | 8h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 26h |
| Travail personnel : | 0h |
| Total : | 26h |

## ASSESMENT METHOD

2 hours an examination written with notes of course2

## TEACHING AIDS

A4 sheet of double-sided personal notes on the course

## TEACHING LANGUAGE

French

## CONTACT

M. MASENELLI Bruno :
bruno.masenelli@insa-lyon.fr

## AIMS

SKILLS:
Contribution to the development skills 1 and 2 of the RNCP sheet of the department.
Mastery of the physics of materials and semiconductor devices.

OBJECTIVES:
Acquire basic knowledge of the physical properties of materials and semiconductor devices and elementary components.
After the course, students should: understand the optical, electrical and transport properties of semiconductors, know the basic physical principles governing the performance of components, be able to use basic equations describing the characteristics of devices.

## CONTENT

- Physics of semiconductors:
Recall on PN junction and bases on heterojunctions - Metal-semiconductor contact (ohmic contact - Schottky barrier) - Semiconductor heterojunction / semiconductor -

- Optoelectronic components:
Physics of light emitters and receivers - Simple applications of heterojunctions: photovoltaic cells, light-emitting diodes (LEDs), PIN photodiode, laser diodes.

## BIBLIOGRAPHY

[1] « Physique des semi-conducteurs » B.SAPOVAL C.HERMANN, Ed. Ellipse (1990)

[2] «Composants à Semi-Conducteurs : de la Physique du Solide aux Transistors» O. BONNAUD, Ed.Ellipses (2007)

[3] « Dispositifs et circuits semi-conducteurs » Physique et Technologie ; A.VAPAILLE, R.CASTAGNE Ed. Dunod (1990)

[4] « Semiconductor devices: physics and technology » S.M. SZE, Ed. J. Wiley (1985)

[5] « Physique des semi-conducteurs et les composants électroniques », H. MATHIEU, Ed. MASSON

## PRE-REQUISITES

Basic Solid State physics course

Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Semiconductor and MEMS materials and components technology

## IDENTIFICATION

CODE : MT-4-S1-EC-TELEMS
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 22h |
| TD : | 4h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 26h |
| Travail personnel : | 0h |
| Total : | 26h |

## ASSESMENT METHOD

A 2 hour written exam

## TEACHING AIDS

A4 sheet of double-sided personal notes on the course

## TEACHING LANGUAGE

French

## CONTACT

M. FOURMOND Erwann :
erwann.fourmond@insa-lyon.fr

## AIMS

SKILLS:
Contribution to the development skills 1 and 2 of the RNCP sheet of the department.
Mastery of materials technology and semiconductor devices.

OBJECTIVES:
Acquire the basic knowledge of the physical properties of semiconductors, materials technology and semiconductor devices and elementary components.
After the course, the students should: know different semiconductor, dielectric and metallic materials and their main properties, know the different techniques of elaboration of these materials, their advantages and disadvantages,
And to be able to choose between different technological approaches of materials and semiconductor components for their realization.
Acquire basic multi-physics knowledge for modeling, design, fabrication and characterization of micro-nanosystems components (MEMS and MOEMS).

## CONTENT

- Semiconductor technology and devices:
General introduction - Elaboration of semiconductor substrates (Method CZ, FZ, Bridgman) - Elaboration of active layers (epitaxies, CVD deposition, thermal diffusion, ion implantation) - Growth and deposition of dielectric layers - Photolithography techniques - Realization of elementary components (MOS transistor, CMOS inverter).

- Silicon micro-nanotechnology for MEMS: technology and architecture:
Introduction - MEMS Development Context - Transduction Phenomena Implemented in MEMS - Micro-machining and Silicon Micro-technologies - Examples of MEMS - Towards nanotechnologies.

## BIBLIOGRAPHY

. Semiconductor Devices: Physics and Technology, 3rd Edition Simon M. Sze, Ming-Kwei Lee ¿ Ed. Wiley (2012)

. Dispositifs et circuits semi-conducteurs : Physique et Technologie ; A.VAPAILLE, R.CASTAGNE Ed. Dunod (1990)

. Silicon Microsensors, S.M. Sze, Wiley, 1993

. Dispositifs et physique des microsystèmes sur silicium, S. Mir, Lavoisier, 2002

## PRE-REQUISITES

# TP semiconductor materials and components

## IDENTIFICATION

CODE : MT-4-S1-EC-TPMASC
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 52h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 52h |
| Travail personnel : | 0h |
| Total : | 52h |

## ASSESMENT METHOD

Lab report + oral defense

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. MANDORLO Fabien :
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## AIMS

Acquisition of working methods and of knowledge to analyze and interpret the properties of semiconductor materials and components
To familiarize the students with techniques for the engineer on fields of the development and characterization of semiconductor materials. Study of the technological processes and the electric behaviour of semiconductor devices.

## CONTENT

- Semiconductor light emitters (LED, laser diodes) and optical fibers
- Atomic Force Microscopy (AFM)- analysis
- Photovoltaic Solar cells
- Doping of semiconductors : thermal diffusion
- Ellipsometry
- Characterization of MOS-FET transistor
- Characterization of MOS-bipolar transistor
- Electric simulation of MOS and bipolar transistors
- Process simulation of bipolar transistor
- Process simulation of MOS transistor
- Project of simulation
- photolithographie processes.

## BIBLIOGRAPHY

[1] H. MATHIEU - Physique des semiconducteurs et des composants électroniques, Ed. Masson 1990

[2] A.VAPAILLE, R. CASTAGNE - Dispositifs et circuits intégrés semiconducteurs - Physique et Technologie, Ed Dunod (1990)

[3] S. M. SZE - Semiconductor devices : Physics and Technology, Ed. J.Wiley (1985)

## PRE-REQUISITES

# Ceramics and glass

## IDENTIFICATION

CODE : MT-4-S1-EC-CERAVER
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 12h |
| TD : | 6h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 18h |
| Travail personnel : | 0h |
| Total : | 18h |

## ASSESMENT METHOD

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. JORAND Yves :
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## AIMS

Know the main class of ceramic materials and their specific characteristics. To be able, on a general point of vue, to identify composition, structure and microstructure wich fits the properties required for a an application. Have the skills to apply general principles of divided materials processing to typical ceramic elaboration cases.
Basic formation on ceramic science and powder technology

## CONTENT

First part.
Definition and classes of ceramics. Description of the links between the atomic bonds, structures , typical microstructures, and the main properties and applications (mechanical, fonctionals, traditionals, construction, ...). General principles of fabrication of the various classes of ceramics.
Second part. Ceramic and divided materials processing. Surfaces and interfaces thermodynamics, surface forces, mineral powders synthesis, divided materials caracterization, solid state sintering, liquide phase sintering, basic sintering models, powders flow, packing and compaction, Pastes and suspensions rheology, description of the mineral-solution interface, electrochemistry of suspensions, basics of process science.

## BIBLIOGRAPHY

- M. F. Ashby, D.R.H. Jones, Matériaux, Dunod, 1991
- Traité des Matériaux, Presses Polytechniques et Universitaires Romandes,1999-
- A.J. Moulson, J.M. Herbert, Electroceramics, Chapman et al., 1993
- J.S. Reed, Principles of ceramics processing, Wiley inter-science, 1994
- T. Allen, Powder sampling and particle size determination, Elsevier, 2003
- R. M. German, Particle packing characteristics, Metal Powder Industries Federation, 1989
- W. D. Kingery, H. K. Bowen, D. R. Uhlmann, Introduction to ceramics, 1976
- D. Bernache-Assollant, Chimie-physique du frittage, Hermes, 1993
- J.P. Jolivet, De la solution à l'oxyde, EDP Sciences Editions, 1994
- Gouttes, bulles, perles et ondes, P-G de Gennes, F. Brochard-Wyart, D. Quéré, Belin, 2002

## PRE-REQUISITES

Basic knowledge in material science

# Material Mechanics

## IDENTIFICATION

CODE : MT-4-S1-EC-COMPMM
ECTS : 6

## HOURS

| | |
|---|---|
| Cours : | 22h |
| TD : | 16h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 38h |
| Travail personnel : | 0h |
| Total : | 38h |

## ASSESMENT METHOD

One exam (3h) at the end of the semester. 2 written short evaluations during the courses (1h)

## TEACHING AIDS

## TEACHING LANGUAGE

English

## CONTACT

M. CHEVALIER Jerome :
jerome.chevalier@insa-lyon.fr

## AIMS

- Realisation and analysis of standard mechanical tests (traction, flexion, compression, hardness). Determination of intrinsic mechanical properties.
- Understanding of microstructure ¿ mechanical properties relations.
- Knowledge of damage criteria (for plastic or brittle behavior), at the microscopic or macroscopic scale.
- Determination, for simple cases, of performance index of materials for mechanical applications. Materials selection.

Basic knowledge of mechanical behavior of materials. Microstructure-mechanical properties relations. Introduction to failure, fatigue, creep.

## CONTENT

Introduction.
Chapter I : Mechanical tests and simple mechanical laws.
Chapter II : Physics of plasticity (following one course of 3 SGM)
Chapter III : Mechanics of plasticity
Chapter IV : Some elements of brittle failure
Chapter V : Fatigue and creep
Chapter VI : Materials selection

## BIBLIOGRAPHY

[1] J.M DORLOT et al. "Des matériaux" ed. Ecole Polytechnique de Montreal, 3ème édition, juin 2002,
ISBN-13 : 978-2-553-00770-5
[2] W.D. Callister, `Materials Science and Engineering¿, Wiley et sons, 6International Ed (20 août 2002),
ISBN-13: 978-0471224716.
[3] H.W HAYDEN "The structure and properties of materials" Vol.III Mechanical behaviour John Wiley and Sons 1965,
[4] J. Philibert et al. `Metallurgie générale¿, ed. Masson et Cie. 1969

## PRE-REQUISITES

Basic knowledge of mechanics (RDM, 3 SGM) and physics of defects in materials (solide réel 3 SGM)

# Corrosion and durability of materials

## IDENTIFICATION

CODE : MT-4-S1-EC-CORROD
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 14h |
| TD : | 10h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 24h |
| Travail personnel : | 0h |
| Total : | 24h |

## ASSESMENT METHOD

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. NORMAND Bernard :
bernard.normand@insa-lyon.fr

## AIMS

Basic knowledge in Corrosion Science in order to :
- recognize and understand a corrosion case, whatever the industrial field, the environment and the material,

- be able to propose an efficient remedy,

- participate (with designing people) to the best choice for a new plant or for a newindustrial or domestic structure.

## CONTENT

- Oxidation and dry corrosion : thermodynamic and kinetic aspects, high temperature oxidation of alloys, protection concepts, effects of S, C.....

- Electrochemistry and corrosion: thermodynamic and kinetic aspects; polarization diagrams, passivity of alloys...

- Corrosion protection: cathodic protection, anodic passivation, coatings, inhibitors.

- Industrial aspects of corrosion: corrosion modes, economical aspect.

## BIBLIOGRAPHY

[1] D.LANDOLT, Corrosion et Chimie des Surfaces de métaux. Presses Polytecniques et Universitaires Romandes 1993
[2] M.G FONTANA, N.D GREENE, Corrosion Engineering, Mc Graw Hill 1967
[3] H.H UHLIG and R.W REVIE - Corrosion and Corrosion Control, J.Wiley and Sons 1985
[4] S. AUDISIO - le livre Multimédia de la corrosion, IIéme edition, INSA lyon, Laboratoire de Physico-Chimie Industrielle
[5] B. NORMAND, N. PEBERE, C. RICHARD, M. WERY : Prévention et lutte contre la corrosion : Une approche scientifique et technique, Pub. By PPUR coll. INSA de Lyon, 2004

## PRE-REQUISITES

Basic metallurgical and physicochemical knowledge

Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Metallurgy

## IDENTIFICATION

CODE : MT-4-S1-EC-METSTR
ECTS : 6.00

## HOURS

| | |
|---|---|
| Cours : | 30h |
| TD : | 16h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 46h |
| Travail personnel : | 0h |
| Total : | 46h |

## ASSESMENT METHOD

- theory and seminars : one written examination (3 hours

## TEACHING AIDS

Polycopies

## TEACHING LANGUAGE

French

## CONTACT

M. KLEBER Xavier :
xavier.kleber@insa-lyon.fr

## AIMS

Basic knowledge of the microstructural transformations in metallic alloys. Relation between their microstructure and service properties.

## CONTENT

Microstructural transformations in metals and metallic alloys :
- Recovery, recrystallization,
- Precipitation,
- Martensitic transformation
- Solidification
- Heat treatments (TTT and CCT curves....)
- Application to particular cases (microstructure - properties relations) :
- Aluminium alloys (heat treatable and cast alloys)
- Ferrous alloys (very low carbon steels, heat treatable engineering steels, cast-irons)
- Alloys for specific use (stainless steels, superalloys, Ti alloys)

## BIBLIOGRAPHY

[1] M.F ASHBY, D. R.H. JONES, « Matériaux 1 et 2 » Ed. Dunod, 1991

[2] W. KURZ, J.P MERCIER, G.ZAMBELLI « Introduction à la Science des Matériaux » Presses Polytechniques Romandes, 1987

[3] J.M DORLOT, J.P BAILON, J.MASOUNAVE,« Des Matériaux » Ed. de l'Ecole Polytechnique de Montréal, 1986

[4] J. BARALIS, G.MAEDER, « Précis de Métallurgie » Ed. Afnor-Nathan, 1986

[5] J.PHILIBERT et al « Métallurgie du minerai au Matériau » Ed. Masson, 1998

## PRE-REQUISITES

Structural Characterization (3MT-CARAC-1)
Real Solid and Equilibrium diagrams (3MT-REASOL-2)
Mechanics of solids and elasticity (3MT - MESOEL-2)

# Practical Physical chemistry and mechanics of materials

## IDENTIFICATION

CODE : MT-4-S1-EC-TPPCMM
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 60h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 60h |
| Travail personnel : | 0h |
| Total : | 60h |

## ASSESMENT METHOD

Assessment of the work done during the session with a mark + a report at the end of each session in the form of a questionnaire. At the end of the term an individual oral examination (30min).

## TEACHING AIDS

Polycops

## TEACHING LANGUAGE

French

## CONTACT

MME JOLY POTTUZ :
lucile.joly-pottuz@insa-lyon.fr

## AIMS

Relationships between the microstructure of these materials and their mechanical, physical and physicochemical properties. How to improve these properties through heat or thermomechanical treatments.
Characterisation of the engineering materials and of their behaviour. To show how it is possible to modify the microstructure of metals and alloys using heat or thermomechanical treatments.

## CONTENT

- Characterization of the mechanical behaviour (tensile test, creep, fatigue, strength of a unidirectionnal composite)
- Microstructure - mechanical properties relationships (hardening methods, restoration-recrystallization)
- Phase Transformations (solidification microstructures, precipitation hardening, martensitic transformation and shape memory alloys)
- Engineering steels heat treatments (austenitization and annealing, quenching and tempering)
- Materials damage (corrosion, thermal shock of ceramcis)
- Analysis and characterization methods (EDX microanalysis, crystallinity ratio measurement by X ray diffraction, glassy materials studied by DSC measurements)

## BIBLIOGRAPHY

[1] J.P BAïLON, J.M DORLOT « Des Matériaux » 3ème Edition Presses Internationales Polytechnique (2000)

[2] M.F. ASHBY, D.R JONES « Matériaux 1 et 2 » Ed. DUNOD (1991)

[3] J BARALIS, G.MAEDER « Précis de Métallurgie » Ed. AFNOR-NATHAN (1986)

[4] J. PHILIBERT et al « Métallurgie du minerai au matériau » Ed. MASSON (1998)

[5] D.A. PORTER and K.E. EASTERLING "Phase transformations in Metals and Alloys" Chapman et Hall (1992)

## PRE-REQUISITES

Materials Characterisation Course MT-3-S1-EC-CARPLAS
Materials Microstructures Course MT-3-S1-EC-MICRODD
Mechanics of materials course MT-3-S2-EC-MECA
Practicals on measurements methods MT-3-S1-EC-TPMES

# Non-destructive testing

## IDENTIFICATION

| | |
|---|---|
| CODE : | MT-4-S2-EC-CND |
| ECTS : | 3.00 |

## HOURS

| | |
|---|---|
| Cours : | 10h |
| TD : | 6h |
| TP : | 16h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 32h |
| Travail personnel : | 0h |
| Total : | 32h |

## ASSESMENT METHOD

An 3-hour exam at the end of the second semester.

Laboratory report

## TEACHING AIDS

Slides, board

## TEACHING LANGUAGE

French

## CONTACT

M. LETANG Jean :
jean-michel.letang@insa-lyon.fr

## AIMS

To understand the role and the stakes on nondestructive testing (NDT) in the industrial framework for material science. To deepen, from theoretical bases to applications, three standard techniques in NDT : eddy current testing (ET), ultrasonic testing (UT) et radiology testing (RT).

To master and to implement standard of nondestructive testing (NDT) in the industrial framework for material sciences : eddy current testing (ET), ultrasonic testing (UT) et radiology testing (RT).

## CONTENT

General introduction on NDT. Principle, physical bases et application domains for each of the 3 techniques ET, UT et RT.

A laboratory day dedicated to each of the 3 techniques ET, UT et RT.

## BIBLIOGRAPHY

[1] Introduction to nondestructive testing: a training guide, P. Mix, Wiley, 2005.
[2] Handbook of Nondestructive Evaluation, C. Hellier, McGraw-Hill, 2003.
[3] Nondestructive evaluation: theory, techniques and applications, P. Shull, 2002.

## PRE-REQUISITES

Physics and Mathematics Modules of L2 Level.

# Digital materials

## IDENTIFICATION

CODE : MT-4-S2-EC-MATNUM
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 12h |
| TD : | 6h |
| TP : | 24h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 42h |
| Travail personnel : | 0h |
| Total : | 42h |

## ASSESMENT METHOD

- two-hour supervised homework on computer, individual note
- Project report, note by group

## TEACHING AIDS

- Free-access computer room with 45 workstations
- Courses/Tutorial work available on the Moodle digital learning platform

## TEACHING LANGUAGE

French

## CONTACT

M. Morthomas Julien :
julien.morthomas@insa-lyon.fr

## AIMS

Experience is not always enough to understand and predict material behavior. Numerical simulations can provide a valuable solution. They are based on modeling physical phenomena, i.e. putting them into equations. It is often impossible to solve these equations analytically. Robust numerical methods must therefore be used to solve them.

The first objective of this course will be to discuss the various forms of equations encountered in the materials field, i.e. to understand the assumptions underlying a model and the study of these properties, and to propose suitable numerical methods for solving them. The choice of a numerical method will be confronted with the models and the analysis of these properties: convergence, stability, efficiency, error estimation, etc.

The second objective is to write the algorithms for these numerical methods and implement them in Python for examples taken from the materials field: diffusion equation, heat equation, molecular dynamics, etc.

This EC MT-4-S2-EC-MATNUM falls under the Teaching Unit MT-4-UE-S2-SDI-and contributes to:

School skills in science for engineering:
A1 - Analyze a real or virtual system (or problem)
A2 - Use a model of a real or virtual system
A3-Implement an experimental/digital approach

School skills specific to the specialty:
C1-Know and be able to establish the Structures-Properties relationships of Materials
C4-Modeling and predicting the behavior of materials

By mobilizing the following skills:
B2-Work, learn, evolve independently
B3-Interact with others, work in a team

## CONTENT

The first part of the course consists of ten two-hour tutorials, in which the basics of numerical solution of differential equations are explained. During these sessions, different numerical schemes adapted to a physical model will be discussed. These sessions will be supplemented by computer practice in Python.

In the second part of the course, 24 hours of group projects will be carried out in Python on a concrete material problem.

## BIBLIOGRAPHY

- Analyse numérique et équations différentielles, EDP Science, 2006
- Équation aux dérivées partielles, Dunod, 2022

## PRE-REQUISITES

Basic knowledge of Python programming.

# Finite elements

## IDENTIFICATION

CODE : MT-4-S2-EC-ELEFIN
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 8h |
| TD : | 24h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 32h |
| Travail personnel : | 0h |
| Total : | 32h |

## ASSESMENT METHOD

Individual TP + Oral report of 20 minutes

## TEACHING AIDS

## TEACHING LANGUAGE

French
English

## CONTACT

M. FABREGUE Damien :
damien.fabregue@insa-lyon.fr

## AIMS

Finite Elements Method.
To give the basics of the finite element method applied to mechanics. To outline the main difficulties arising in the resolution of problems.

Learn how to use a finite elements software.

Working in group to solve a problem thanks to the finite elements method.

## CONTENT

FINITE ELEMENT METHOD : AN INTRODUCTION

. Interest ot the method

. General overview of the method

. Theoretical aspects

. The differents type of elements

. Convergence

. Boundary conditions

. Non linearity

. Damage PRATICAL

. 2D and 3D static calculations

. Projects (group of 2/3 students

## BIBLIOGRAPHY

[1] K.J Bathe, Finite Element Procedures, Prentice Hall, Englewood Cliffs, New Jersey, 1996 (DI)
[2] D. dhatt, G. Touzot, une présentation de la méthode des éléments finis, 2ème éd., Maloine, Paris, 1984 (BU)
[3] O.C Zienkiewicz, R.L Taylor, The finite element method, Mc Graw-Hill, New-York, 1989 (BU)
[4] M. Rappaz, M. Bellet, M. Deville, Traité des matériaux, Vol.10, Modélisation numérique en science et génie des matériaux, presses polytechniques et universitaires romandes, 1998 (DI)

## PRE-REQUISITES

Basic Knowledge of mechanics

# Design of experiments

## IDENTIFICATION

CODE : MT-4-S2-EC-PLEXPE
ECTS : 1.00

## HOURS

| | |
|---|---|
| Cours : | 11h |
| TD : | 0h |
| TP : | 8h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 19h |
| Travail personnel : | 0h |
| Total : | 19h |

## ASSESMENT METHOD

Each groupe have to make detailed report explaining the different stages of their work (selection of the matrix, number of shots ...). This report is evaluated by a mark.

## TEACHING AIDS

1 polycop

on line site on Moodle

## TEACHING LANGUAGE

French

## CONTACT

MME STEPHAN Pascale :
pascale.stephan@insa-lyon.fr

## AIMS

Give the fundamentals to make a design of experiments by Tagushi methods.

## CONTENT

First day :
a. Morning : Theoretical training in the area of the design of experiments, clearly showing the basics. Presentation of the software KitTag for analyzing the results of a design of experiments.
b. Afternoon : Student groups will produce on the design of experiments for optimizing the trajectory of a catapult projectile.
Second day :
a. Morning : Continuation of the practical and performance of the validation experiments.
b. Afternoon : Each group makes a report, asesseb by an professional expert who analyses and criticize the work of the groups and etail shis personal experience.

## BIBLIOGRAPHY

[1] Pratique industrielle des plans d'expériences (AFNOR 1999) de Jacques et Philippe Alexis.

[2] Plans d'expériences. Applications à l'entreprise. Droesbeke, Fine, Saporta. Editions Technip.

## PRE-REQUISITES

Knowledge of standard deviation and mean value

# Personal and Professional Project

## IDENTIFICATION

CODE : MT-4-S2-EC-PPP
ECTS : 0.00

## HOURS

| | |
|---|---|
| Cours : | 4h |
| TD : | 40h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 44h |
| Travail personnel : | 0h |
| Total : | 44h |

## ASSESMENT METHOD

Compulsory participation
(exercices, training, role plays)

## TEACHING AIDS

Conferences et hosted workshops
(PPP teaching aid)

## TEACHING LANGUAGE

French

## CONTACT

MME SANCHEZ FORSANS :
sylvie.sanchez-forsans@insa-lyon.fr

## AIMS

The main objective of this course is to allow each student to participate in a brainstorming session and in a professional preparation, individually and in group, to help building and upgrading their Personal and Professional Project (PPP). Moreover, while searching for intership and job opportunities during their engineering degree course at INSA

1. Identify their assets and upgrade their current skills assessments.

2. Build or finalize their professional project(s)

3. Comprehend the job and employment markets (tools provided)

4. Master recruitment techniques (resume, cover letter and job interviews)

5. Upgrade their service offering as an INSA engineer-to-be

## CONTENT

PPP(Personnel Professional Project) importance and benefits
Key guiding principles regarding career management for the INSA engineer-to-be
CARE awareness: Campagne to look actively for a job (8 actions)
Methodology : Assessment of Projects and actions related to job and employment market
Service offering presentation: speaking and written communication
Face to face professional expression (job interviews and networking)
Training key techniques and individual advice

## BIBLIOGRAPHY

APEC Studies and forms related to job descriptions, jobs by industries and jobs by counties, ROME : Occupation and Job Operational Index, investigations career engineers (Alumni INSA) et carrieres.insa-lyon.fr
« How to find a position¿and get the job of your dream» (D.POROT)

## PRE-REQUISITES

PPP form to be filled in during the PPP conference
Jobs or interships openings to be brought to the PPP workshop
Up-to-date resume

# Internship

## IDENTIFICATION

CODE : MT-4-S2-EC-STAGE4
ECTS : 6.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 2h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 2h |
| Travail personnel : | 0h |
| Total : | 2h |

## ASSESMENT METHOD

The course mark is based on the assessment of the tutor/engineer. No
course report is required. At the end of the course, students complete a double-sided A4 recap sheet, which is assessed.

Assessment of the following knowledge:
- ability to adapt to the business world and to the different situations encountered
- ability to organise work and develop methods
- ability to analyse and prioritise a scientific and technological problem
- ability to summarise and present work

Assessment of the following skills:
- ability to work independently or as part of a team, integrating with different working groups

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. Ter-ovanessian Benoit :
benoit.ter-ovanessian@insa-lyon.fr

## AIMS

The 2.5 to 3-month 4th-year placement at the end of the school year (4th year) allows engineering students to:
- apply, compare and perfect their knowledge in the face of concrete cases.
- test their analytical and synthetic abilities in the face of real problems.
- familiarise themselves with the business world and their future profession.

These courses can take place in France or abroad, in SMEs, large industrial groups or research centres. The main task of the engineering students is to carry out the project entrusted to them at the beginning of the course.

This course falls under the SGM-4-UE-PCS-S2 teaching unit,
A1 - Analyse a real or virtual system (or problem)
School skills in humanity, documentation and physical education and sports:
B1 - Self-assess one's own performance (Level 2)
B2 - Work, learn and develop independently (Level 2)
B3 - Interact with others, work in a team (Level 3)
B4 - Demonstrate creativity, innovation and enterprise (Level 2)
B5 - Act responsibly in a complex world (Level 2)
B6 - Position oneself, work and develop in a company or socio-productive organisation (Level 3)
B7 - Work in an international and intercultural context (Level 3)
By mobilising the following competences:
A2 - Use a model of a real or virtual system
A3 - Implement an experimental approach
A4 - Design a system that meets specifications
A5 - Process data
A6 - Communicate a scientific analysis or approach with scenarios adapted to their speciality
C1 - Know and be able to establish the structure-property relationships of materials
C2 - Identify and implement methods for developing materials
C3 - Apply materials
C4 - Model and predict the behaviour of materials

## CONTENT

## BIBLIOGRAPHY

## PRE-REQUISITES

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

**Ingénieur, spécialité matériaux**

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Collective materials projects

## IDENTIFICATION

CODE : MT-4-S2-EC-PCOMAT
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 27h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 27h |
| Travail personnel : | 0h |
| Total : | 27h |

## ASSESMENT METHOD

The evaluation of the project is based on the submission of a final report to the various tutors, as well as on a plenary defense of the project in front of the other students and a jury of teachers.
Absence from management and CSR courses results in non-validation of the module

## TEACHING AIDS

Making contact with professional circles
The Human Element by Will Schultz
From performance to excellence by Jim Collin
Social psychology of sport S Jowett and D Lavallee
Marston's communication model
The efforts of Hervé Seryex's manager

## TEACHING LANGUAGE

French

## CONTACT

Mme cazottes sophie :
sophie.cazottes@insa-lyon.fr

## AIMS

This is therefore a project carried out in groups of 5 to 7 pupils, which leads to the exploration of different solutions to a complex scientific and technical problem, involving multiple skills with an argued choice of solutions. The main part of the work is based on bibliographic research of information.

This EC is part of the MT-4-UE-S2-PCS teaching unit and contributes to the following:

School skills in engineering sciences:
A1 - Analyse a real or virtual system (or problem) (Level 2)
A2 - Use a model of a real or virtual system (Level 1)
A4 - Design a system that meets specifications (Level 3)
A5 - Process data (Level 1)
A6 - Communicate a scientific analysis or approach with scenarios adapted to their speciality (Level 1)

Skills in humanities, documentation and physical education and sports:
B1 - Self-assess one's own performance (Level 2)
B2 - Work, learn and develop independently (Level 2)
B3 - Interact with others, work in a team (Level 3)
B4 - Demonstrate creativity, innovation and enterprise (Level 2)
B5 - Act responsibly in a complex world (Level 1)

School-specific skills for the specialism:
C1 - Know and be able to establish the structure-property relationships of materials (Level 2)
C2 - Identify and implement methods for developing materials (Level 1)
C5 Innovate and research materials (Level 2)

By mobilising the following skills:
A3 - Implement an experimental approach
B6 - Position oneself, work and develop in a company or socio-productive organisation
C4 - Model and predict the behaviour of materials

By enabling the student to work and be assessed on the following knowledge:

- To train the student engineer to experience the relationships, organisation and management (practices and constraints) of a project carried out in a team.

- To train in the problems posed by the need to carry out a project in accordance with specifications defined at the outset. To introduce the procedures for writing specifications.

- Integrate knowledge from several disciplines, including documentary or information research. Learn to manage and critique the information found.

- Accustom the student to moving from measuring individual performance (school status) to measuring collective performance, on which he or she is able to identify his or her impact.

- Enable the appropriation of the tools of the human resources engineer: knowledge, methods of analysis and techniques in communication, organisation, group dynamics, running and chairing meetings, regulating tensions, etc.

- Broaden everyone's horizons, both in terms of technical skills in materials or their applications, and in terms of how the industrial world works. Projects can thus contain a societal component.

- Promote subsequent integration of professional networks.

## CONTENT

This project is carried out in groups of 5 to 7 students, under the supervision of a teacher from the department. Most of the projects are the result of a request from an industrialist and, in this case, are also supervised by an industrial tutor. In addition, there is a DocINSA tutor assigned to the project, for guidance and the proper management of the bibliographic part.

The pupils have a weekly 2-hour slot reserved for the project. In addition to this, there is the Methodology of documentary research (DocINSA Managers: Evelyne Chataignon, Nicole Goetgheluck)

Objective: Training in the search for bibliographic information. Presentation of scientific databases and different search engines. Presentation of tools for managing bibliographic data and for writing scientific reports. Management of heuristic diagrams.

## BIBLIOGRAPHY

Professional relations with industrial partners

## PRE-REQUISITES

General knowledge of materials

# Responsible project management

## IDENTIFICATION

CODE : MT-4-S2-EC-INSPIRE
ECTS : 0.00

## HOURS

| | |
|---|---|
| Cours : | 8h |
| TD : | 48h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 56h |
| Travail personnel : | 0h |
| Total : | 56h |

## ASSESMENT METHOD

Collective evaluation of the project groups via
- a visual oral pitch
- a written report
- an oral defense

and supplemented by monitoring throughout the project:
- formal and informal project reviews
- weekly report of work accomplished and distribution of tasks within the group

## TEACHING AIDS

- Contributions, applications and project review in TD
- Conferences in CM
- Hybrid project tutoring (face-to-face / remote & synchronous / asynchronous according to needs)

## TEACHING LANGUAGE

French

## CONTACT

MME FREZET MULLER :
virginie.muller@insa-lyon.fr

## AIMS

This EC contributes to the following humanities competencies:
- B3 Interacting with others, working in a team (level 3)
- B5 Acting responsibly in a complex world (level 3)
- B6 Positioning oneself, working, evolving in a company, a socio-productive organization
The associated ECTS credits are DDRS dedicated and cover several elements of the 5 items of the DDRS roadmap.

It allows the student to work and be assessed on the following knowledge & skills:
- Setting up a real or realistic responsible collective project in support of the field
- Consideration of socio-ecological issues in the choice of the purpose of the project
- Applied Design Thinking approach
- Study of the socio-ecological impacts of the project
- Collective intelligence and project management methodology
- Professional presentation of his work in different ways (defense, pitch, project review)

## CONTENT

LAUNCH
- Presentation of the module & choice of groups

IDEATION
- Socio-ecological issues: global earth system, biodiversity, climate and resources
- Social issues: precariousness, discrimination, intersectionality
- Presentation of inspiring positive engineering initiatives and projects related to socio-ecological issues
- Sensitive and personal approach to socio-ecological issues
- Building a shared vision
- Design thinking approach: creativity and representation of the idea / use / users

FEASIBILITY STUDY
- Organizational and human project management methodology
- Methodology for assessing socio-ecological impacts: table for studying social impacts / LCA
- Methodology for setting up a responsible project: strategy, ecosystem, governance, financing, legal and administrative formalities and visual identity.
- Design thinking approach: iterative tests and feedback from users and experts

## BIBLIOGRAPHY

Pour une écologie du sensible, Jacques Tassin

Le design thinking au service de l'innovation responsable - X. Pavie, C. Jouanny, D. Carthy, F. Verez

## PRE-REQUISITES

# Polymer materials: solid-state properties and viscoelasticity

## IDENTIFICATION

CODE : MT-4-S2-EC-POLYPHYS
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 16h |
| TD : | 10h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 26h |
| Travail personnel : | 0h |
| Total : | 26h |

## ASSESMENT METHOD

1.30 hour written exam without course documents

## TEACHING AIDS

- Course support slides (in English and French)
- Handout of tutorial exercises (in English and French)

## TEACHING LANGUAGE

French

## CONTACT

M. GERARD Jean-Francois :
jean-francois.gerard@insa-lyon.fr

## AIMS

The aims of this teaching module are to introduce the main concepts relating to the physical properties of polymers in the solid state (and molten state for thermoplastics) in order to be able to associate them with architectures on the macromolecular scale and with morphologies by emphasizing the specificity of polymers, which is molecular mobility. For this type of material, physical behavior is highly dependent on the temperature and/or speed of stress (or time or frequency). The important concepts for describing physical behavior (viscoelastic in the molten and solid state, mechanical at large deformations and electrical/dielectric), including in terms of models, will be presented.

## CONTENT

A.- VISCOELASTIC BEHAVIOUR OF POLYMERS
1 - INTRODUCTION
2.- PHENOMENOLOGICAL APPROACH
2.1 Definitions
Hooke's solid and Newton's liquid: Moduli and viscosity
2.2 Viscoelastic behavior
Creep and relaxation experiments
2.3 Boltzmann's Superimposition Principle
2.4 Viscoelastic Models
2.5 Dynamic Mechanical Behavior
2.6 - Time(frequency)-temperature relationship
3.- VISCOELASTIC BEHAVIOUR OF POLYMERS: RELATIONSHIPS WITH THEIR MICROSTRUCTURE AND MORPHOLOGY
3.1 - Viscoelastic spectra
Main transition a and secondary relaxations / Examples
Molecular relaxation map
Analogy with other spectroscopies /
Molecular mobility in the solid state
3.2.- Illustrations of the influence of the main molecular parameters
Amorphous polymers
Microstructure, molar mass, networks (cross-linking density)
Polymer blends and copolymers
Semi-crystalline polymers
Filled polymers

B.- RHEOLOGICAL BEHAVIOUR OF POLYMERS IN THE MOLTEN STATE
1.- INTRODUCTION
1.1. - Definition
1.2. - Rheological phenomena
2 - NON-NEWTONIAN FLUIDS
2.1. - Definitions and Applications
Newtonian fluids, shear-thinning fluids, shear-thickening fluids, threshold fluids
2.2. - Classification and viscosity models
3 - LINEAR VISCOELASTICITY
3.1. - Definitions and principles
3.2. - Linear models
3.3. - Measurement Systems - Steady State Rheometry
3.4. ¿ Influence of macromolecular parameters

C.- MECHANICAL BEHAVIOUR OF POLYMERS UNDER LARGE DEFORMATIONS
1.- MOLECULAR MECHANISMS OF POLYMER DEFORMATION AND FRACTURE
1.1 - Experimental approach
Bond extension and deformation
Bond breakage
Creation of microvoids
1.2 - Polymer behavior
Amorphous thermoplastic polymers
Semi-crystalline polymers
Cross-linked polymers (networks)
1.3 Theoretical approaches
2 - CRAZING AND SHEAR
2.1 - Shear and cracking - Demonstration
2.2 Plasticity and cracking criteria
2.3 Interactions between shear and cracking
3 - FRACTURE
3.1 Fatigue fracture
3.2 - Fracture mechanics of polymers

D.- ELECTRICAL AND DIELECTRICAL BEHAVIOUR OF POLYMERS
1 - INTRODUCTION
1.1 - Electrical stresses

1.2 Type of polarization
2 - STUDY OF THE RESPONSE OF POLYMERS TO AN ELECTRIC FIELD
2.1 Resistance and resistivity
2.2 Dielectric strength
3. STUDY OF THE RESPONSE OF POLYMERS TO AN ALTERNATING ELECTRIC FIELD
3.1 - Dielectric constant
3.2 - Dissipation or loss factor
3.3 - Cole-Cole diagram
3.4 - Behavior of polymers
3.5 Electrical measurement techniques
4.- FACTORS INFLUENCING ELECTRICAL BEHAVIOUR

## BIBLIOGRAPHY


- Viscoelastic Properties of Polymers. 3rd Edition. J.D. Ferry. ¿ Wiley¿Blackwell (1980)

- De la macromolécule au matériau polymère - Synthèse et propriétés des chaînes. J.L. Halary, F. Lauprêtre. Belin Education Echelles (2006)

- Mécanique des matériaux polymères. J.L. Halary, F. Lauprêtre. Belin Education Echelles (2008)

- ¿ Polymer Rheology. LE. Nielsen. Marcel Dekker (1977)

- Rheology: Principles, Measurements, and Applications. C.W. Macosko. Wiley VCH (1994)

- Electrical Properties of Polymers 2nd Edition. T. Blythe, D. Bloor. Cambridge Edtions (1987)

- Electrical Properties of Polymers. E. Riande, R. Diaz-Calleja. CRC Press (2004)


## PRE-REQUISITES

The concepts of stresses and strains in the different modes as well as those of modulus of elasticity, viscosity, etc. will need to be assimilated.
Knowledge of the quantities and parameters associated with the main families of polymers (amorphous and semi-crystalline thermoplastics, networks - or thermosets) is required.
Formalizing behavior and its dependence on parameters such as temperature, time, state of stress, etc. requires the ability to handle differential equations, complex calculations and tensor calculations

# TP Characterization of semiconductor components

## IDENTIFICATION

CODE : MT-4-S2-EC-TPCCSC
ECTS : 1.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 12h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 12h |
| Travail personnel : | 0h |
| Total : | 12h |

## ASSESMENT METHOD

Report by pair at the end of each session

## TEACHING AIDS

Handouts

## TEACHING LANGUAGE

French

## CONTACT

M. MILITARU Liviu :
liviu.militaru@insa-lyon.fr

## AIMS

This course aims to consolidate knowledge of the operating foundations of bipolar and MOS transistors, by combining electrical characterization with modeling/simulation of the two components.

This EC falls under the MT-UE-SDM S2 Teaching Unit, Materials S2 and contributes to:

School skills in science for engineering:
A1 - Analyze a real or virtual system (or problem) (Level 1)
A2 - Use a model of a real or virtual system (Level 1)
A3 - Implement an experimental approach (Level 1)
A5 - Process data (Level 5)

School skills in humanity, documentation and physical and sports education:
B2 - Work, learn, evolve independently (Level 1)
B3 - Interact with others, work in a team (Level 1)

School skills specific to the specialty:
C1 - Know and be able to establish the Structures-Properties relationships of Materials (Level 1)
C3 - Apply materials (Level 1)

By mobilizing the following skills
C4 - Model and predict the behavior of materials

By allowing the student to work and be evaluated on the following knowledge:

- know the operating principles of bipolar and field effect transistors,

- know how to carry out basic electronic assemblies in order to measure the current-voltage characteristics of the two types of transistors

- understand how parameters influence the characteristics of transistors.

By allowing the student to work and be evaluated on the following abilities:

- be able to determine the different parameters from experimental data

## CONTENT

Electrical characterization of MOS transistors

Electrical characterization of bipolar transistors

Modeling and simulation of current-voltage characteristics of MOS and bipolar transistors

## BIBLIOGRAPHY

.H. Mathieu ¿Physics of semiconductors and electronic components¿, Ed. Masson

## PRE-REQUISITES

Semiconductor physics, PN junction, MOS capacitance.

Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# TP Elaboration and characterization of Macromolecular Materials

## IDENTIFICATION

CODE : MT-4-S2-EC-TPELACARMM

ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 40h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 40h |
| Travail personnel : | 0h |
| Total : | 40h |

## ASSESEMENT METHOD

5 Report for graded practical work

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. Massardier Valérie : valerie.massardier-nageotte@insa-lyon.fr

## AIMS

1.Carry out and observe a wide range of laboratory experiments.
2.Learn to use technical and scientific results and documents.
3.Prepare students for optimisation and control of the different stages of polymer manufacturing and control (studies of polymer manufacturing techniques, characterisation, establishment of structure/shaping/properties relationships of polymers).
4.Integrate and apply safety rules in a chemistry laboratory.
5.Minimise the environmental impact of practical work.
6.Consider the environmental impact of industrial processes and materials

## CONTENT

Processes and characterisation of amorphous and semi-crystalline polymers
Monitoring of network formation
Shaping processes
Rheology and polymer flow
Characterisation of surfaces and interfaces

## BIBLIOGRAPHY

[1] : Recueil de travaux pratiques édité par le Groupe Français d'études et d'applications des Polymères (GFP)

## PRE-REQUISITES

MT-3-S1-EC-PCMMOL Physico Chemistry of Macromolecular Materials
MT-3-S1-EC-TPMES: Materials Optoelectronic Measurements

Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# MOS semiconductor components

## IDENTIFICATION

CODE : MT-4-S2-EC-COMSEM
ECTS : 2.00

## HOURS

| | |
|---|---|
| Cours : | 12h |
| TD : | 10h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 22h |
| Travail personnel : | 0h |
| Total : | 22h |

## ASSESMENT METHOD

A 2-hour written exam at the end of the semester

## TEACHING AIDS

A4 sheet of double-sided personal notes on the course

## TEACHING LANGUAGE

French

## CONTACT

M. Fourmond Erwann :
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## AIMS

SKILLS:
Contribution to the development skills 1 and 2 of the RNCP sheet of the department.
Mastery of materials technology and semiconductor devices.

OBJECTIVES:
Acquire basic knowledge of the physical properties of semiconductor devices and elementary components.
After the course, students should: understand the electrical and transport properties of semiconductors, know the fundamental physical principles governing the performance of components, be able to use the basic equations describing the characteristics of devices,

## CONTENT

- JBT Junction Bipolar Transistor:
Physics and operation of bipolar transistor NPN and PNP

- Field effect transistors:
Physics and operation of field effect transistors (JFET and MESFET)
Physics of the MOS (Metal-Oxide-Semiconductor) Capability and Operation of the MOS Transistor

## BIBLIOGRAPHY

[1] « Les composants semi-conducteurs » B.BOITTIAUX, Lavoisier Tec et Doc (1991)

[2] «Composants à Semi-Conducteurs : de la Physique du Solide aux Transistors» O. BONNAUD, Ed.Ellipses (2007)

[3] « Dispositifs et circuits semi-conducteurs » Physique et Technologie ; A.VAPAILLE, R.CASTAGNE Ed. Dunod (1990)

[4] «Physics of Semiconductor devices » S.M. SZE, Third edition-J. Wiley (2007)

## PRE-REQUISITES

Basics of physics and technology of semiconductors

# Composite materials

## IDENTIFICATION

CODE : MT-4-S2-EC-MCOMPO
ECTS : 2.00

## HOURS

| | |
|---|---|
| Cours : | 18h |
| TD : | 2h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 20h |
| Travail personnel : | 0h |
| Total : | 20h |

## ASSESMENT METHOD

Questionnaire

## TEACHING AIDS

Transparencies + notes

English course material

## TEACHING LANGUAGE

French

## CONTACT

M. MEILLE Sylvain :
sylvain.meille@insa-lyon.fr

## AIMS

After the course, the student knows the basics of composite elaboration, their main mechanical properties and has made an example of composite piece design.

OBJECTIVES
The course objective is to show the main particularities of composite materials:
- description of the constituents (matrices, reinforcements) and of the architectures,
- description of the main processing methods
- introduction to the mechanical behaviour of composites and laminates (elastic and ultimate properties, anisotropy).

## CONTENT

Introduction: definition, historical, main applications

Mechanics of 1D lamina:
- Elasticity: stiffness and flexibility matrixes (coupling coefficients)
- Macroscopic mechanical resistance: criteria (max. stress or strain, Tsai-Wu)

Mechanics of laminates:
- Tension, flexion of symmetric laminates
- Introduction to the behaviour of non-symmetric laminates
- Example of composite dimensioning

Constituents of composite materials:
- Fibre: glass, carbon, aramid, steel, natural fibers
- Matrix: organic, metallic, ceramics
- Fibrous reinforcement forms, prepregs

Manufacturing of composite materials: moulding, injection, pultrusion, filament winding

Joining and quality control of composites

## BIBLIOGRAPHY

M. Reyne, Technologies des composites, Hermès, Paris

B.T. Aström, Manufacturing of polymer composites, Chapman & Hall, London

S.W. Tsai, H.T Hahn, Introduction to composite materials, Technomic Pub.

D. Gay, Matériaux Composites », Hermès, Paris

A.K. Kaw, Mechanics of composite materials, CRC Press, New-York

## PRE-REQUISITES

General knowledge in materials science and in mechanics: mechanics of continuous media, theory of elasticity, fracture mechanics, mechanical behaviour of polymers and brittle solids.

# Polymer Materials: Macromolecular Design and Physical Chemistry

## IDENTIFICATION

CODE : MT-4-S2-EC-PC2POLY
ECTS : 3.00

## HOURS

| | |
|---|---|
| Cours : | 16h |
| TD : | 10h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 26h |
| Travail personnel : | 0h |
| Total : | 26h |

## ASSESMENT METHOD

One written examination (1h30)

## TEACHING AIDS

course notes

## TEACHING LANGUAGE

French

## CONTACT

M. FLEURY Etienne :
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## AIMS

The objectives at the end of the course are:
-Basic knowledge of the design of macromolecular networks (thermosets¿)
-Characterization of linear polymers in solution and of macromolecular networks

This EC MT-4-S2-PC2POLY falls under the MT-4-UE-SDM-S2 Material Science Teaching Unit Semester 2 and contributes to:

School skills in science for engineers

A5 - Process data (Level 2)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty (Level 1)

Specialty-specific school skills:
C1 - Knowing and being able to establish the Structure-Property relationships of Materials
(Level 2)
C2 - Identify and implement materials development methods (Level 1)
C4 - Modeling and predicting the behavior of materials (Level 2)

By mobilizing the following skills:
A2 - Use a model of a real or virtual system
A3 - Implement an experimental approach
A4 - Design a system that meets specifications
B2 - Work, learn, evolve independently
C3 - Apply materials

By allowing the student to work and be assessed on the following knowledge:

- Know how to explain the mechanisms of dissolution of polymers in a solvent medium,
- Understand the origins of polymer/solvent interactions,
- Know how to use and understand the equations and relations resulting from the theories of Flory-Huggin and Flory-Krigbaum
- Know and know how to use the characterization techniques of polymers in solution diluted or semi-diluted,
- Know the chemistry of the main crosslinkable materials: polyurethane, unsaturated polyesters, epoxy/amine, silicone, etc.
- Know and know how to explain the phenomena of gelation and vitrification
- Know how to calculate the molar mass between crosslinking nodes.
- Know how to propose recycling methodologies

## CONTENT

Part 1: Polymers in solution
- Solubility and behavior in solution (Flory-Huggins and Flory-Krigbaum).
- Measurement techniques of molar masses
- Application to recycling approaches

Part 2: Polymer networks
- Synthesis and structural transformations (gelation, vitrification, phase diagrams and rheology).
- Characterization of networks (swelling, rubber elasticity), model networks, etc.
- Some examples of processing.
- Thermosets recycling strategies (vitrimers, etc.)

## BIBLIOGRAPHY

[1] L.H SPERLING, Introduction to Physical Polymer Science, John Wiley & Sons, Inc. (2006)
[2] M FONTANILLE, Y GNANOU Chimie et physico-chimie des polymères, Editions Dunod (3ème édition 2013)
[3] JP PASCAULT, H. SAUTEREAU, J. VERDU, RJJ. WILLIAMS Thermosetting Polymeres Editions Dekker (2002)
[4] HH KAUSCH, N HEYMANS, CJ PLUMMER, P DECROLY, Matériaux Polymères : propriétés mécaniques et physiques, Presse polytechnique et universitaires Romandes (2001)
[5] T HAMAIDE, L FONTAINE, JL SIX Chimie des polymères, exercices et problèmes corrigés, Editions Lavoisier (2ème édition 2014)

## PRE-REQUISITES

# Data processing and artificial intelligence

## IDENTIFICATION

CODE : MT-5-S1-EC-DATA
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 12h |
| TD : | 11h |
| TP : | 10h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 33h |
| Travail personnel : | 0h |
| Total : | 33h |

## ASSESMENT METHOD

Project report and oral presentation

## TEACHING AIDS

- Free access computer room with 45 stations
- Course books
- Python program base

## TEACHING LANGUAGE

French

## CONTACT

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## AIMS

Today's materials engineer must be able to understand and analyze large amounts of data to address the multifactorial issues that surround them. This course proposes a training content ranging from data retrieval and exploration (data mining) to analysis and learning (machine learning).

To appropriate the benefits of such approaches, students will have a series of lectures, industry conferences and practical work on databases, their management, exploration and learning in materials science. In addition to the appropriation of fundamental tools and methods for this discipline, students will also be made aware of the limits of such methods and the biases they may entail.

This EC SGM-5-MATNUM falls under the Teaching Unit MT-5-UE-SDM-S1
Materials Semester 1 and contributes to:

Specialty-specific school skills
A1 - Analyze a real or virtual system (or problem) (Level 3)
A2 - Use a model of a real or virtual system (Level 3)
A4 - Design a system that meets specifications (level 3)
A5 - Process data (Level 3)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty (Level 2)
C4 - Modeling and predicting the behavior of materials (level 2)

By mobilizing the following skills:
B2 - Work, learn, evolve independently
B3 - Interact with others, work in a team

## CONTENT

This course consists of

- an introduction to data science and artificial intelligence by an external specialist (2h)

- a hands-on approach to tools and software for practical work and projects (1h)

- a series of 3 general courses (3x2h) on databases, their management, exploration and learning in material sciences

- 2 lectures/courses (2x2h) on concrete examples encountered in industry and in a materials science research laboratory

- 3 practical works (3x4h) to use the tools and concepts learned on simple examples

- a project part (10h) on concrete examples encountered in industry or research

## BIBLIOGRAPHY

- Open Classrooms de Philippe Besse - Groupe INSA

- Livre : Data science from scratch : first principles with python, J. Grus (2019)

## PRE-REQUISITES

Basic programming knowledge

**Ingénieur, spécialité matériaux**

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Materials for energy applications

## IDENTIFICATION

CODE : MT-5-S1-EC-MATENER
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 24h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 24h |
| Travail personnel : | 0h |
| Total : | 24h |

## ASSESMENT METHOD

Synthesis to be written on a given topic
MCQ : the questions will be related to all the courses and seminars

## TEACHING AIDS

Slides will be available on moodle platfrom

## TEACHING LANGUAGE

French
English

## CONTACT

M. FAVE Alain :
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## AIMS

The field of production, storage, transformation and transport of energy is at the origin of profound changes in terms of the definition of materials. The important issues of resource management and CO2 emission limitation require technological innovations which, for the most part, induce severe and specific conditions for the use of materials.

This context allows the student to discover a methodology of design, even innovation, which they can transpose to other fields than energy.

The course is structured with the different modes of energy production and storage.
Some seminars will be provided by outside personalities from the industrial world.
This course aims to enhance and put into perspective all the knowledge on materials acquired during the SGM course.

This EC MT-5-S1-EC-MATENER comes under the MT-5-S1-UE-SDM and contributes to:

School skills in science for engineers:
A1 - Analyze a real or virtual system (or problem) (level 2)
A2 - Use a model of a real or virtual system (level 2)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specificity (level 2)

Specialty-specific school skills:
C1 - Knowing and being able to establish the Structure-Property relationships of Materials (level 2)

By mobilizing the following skills
B2 - Work, learn, evolve independently (level 1)
B3 - Interact with others, work in a team (level 1)
B5 - Acting responsibly in a complex world (level 1)
B7 - Working in an international and intercultural context (level 1)
C2 - Identify and implement materials development methods (level 2)
C3 - Apply materials (level 1)
C4 - Modeling and predicting the behavior of materials (level 1)
C5 - Innovate and research in materials (level 1)

By allowing the student to work and be assessed on the following knowledge:

- Know how to classify the different energy sources and storage means (flow/stock, primary/secondary, controllable/non-controllable, diffuse/concentrated)
- Know the issues related to the use of fossil fuels, renewable energies and energy storage
- Know the different forms of renewable energy (thermal, electrical, etc.) and the different types of energy storage, know the associated orders of magnitude
- Know how to analyze the advantages and disadvantages of the different storage sources and solutions over the entire life cycle (including recycling and dismantling)

By allowing the student to work and be assessed on the following abilities:
- Be able to compare the different sources of energy and storage
- Be able to identify major material issues
- Be able to assess energy production and storage capacities
- Be able to describe the operation of energy production and storage systems

## CONTENT

Introduction: Panorama of energies, depletion of resources, link with the climate, renewable energies, management of intermittency, storage¿
Solar PV energy
CO2-geothermal capture and recovery
Biofuels / biomass and electricity production
Transport, storage, production H2 ¿ Generation of H2 by electrolysis
Materials and internal combustion engine H2
Materials and nuclear energy (fission)
Fuel cells
Materials and electrochemical batteries
Energy Harvesting
Ion polymer battery

## BIBLIOGRAPHY

## PRE-REQUISITES

This course will cover all the materials studied in the MT department. It therefore requires a basic knowledge of materials (metals, ceramics, polymers, semiconductors, etc.)

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# Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
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## Sustainable materials

### IDENTIFICATION

CODE : MT-5-S1-EC-MATRESP
ECTS : 4.00

### HOURS

| | |
|---|---|
| Cours : | 24h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 24h |
| Travail personnel : | 0h |
| Total : | 24h |

### ASSESMENT METHOD

Students will have a 1 hour long exam that will assess the concepts and notions covered in the different chapters and lectures.

### TEACHING AIDS

### TEACHING LANGUAGE

French

### CONTACT

MME MASSARDIER-NAGEOTTE Valerie : valerie.massardier-nageotte@insa-lyon.fr

MME FERRIER Lydie : lydie.ferrier@insa-lyon.fr

M. TER OVANESSIAN : benoit.ter-ovanessian@insa-lyon.fr

## AIMS

- To form students in the design methods of materials and technological objects allowing to answer the present and future environmental challenges.

- To familiarise students with the different concepts and notions inherent in taking into account the expectations of the implementation of a circular economy in the field of materials.

- To raise awareness and provide the keys to further study of the different strategies, common to all families of materials or specific, used to achieve this circularity of materials.

- To allow to recognize the limits and levers of action for the deployment of solutions relating to the design of new materials and objects with low environmental impact, while guaranteeing their economic and societal relevance.

This EC SGM-5-MATRESP falls under the Teaching Unit MT-5-UE-SDM-S1 Engineering Science Semester 1 and contributes to:

School skills in science for engineers:
A1-Analyze a real or virtual system (or problem) (Level 2)
A2-Use a model of a real or virtual system (Level 2)
A4-Design a system that meets specifications (Level 3)
A6-Communicating an analysis or a scientific approach with scenarios adapted to their specificity (Level 2)

Specialty-specific school skills:
C1-Know and be able to establish the Structure-Property relationships of Materials (Level 2)
C2-Identify and implement materials development methods (Level 3)
C3-Apply materials (Level 2)
C5-Innovate and research in materials (Level 3)

By mobilizing the following skills:

B2-Work, learn, evolve independently
B4-Demonstrate creativity, innovate, undertake
B5-Act responsibly in a complex world
B7-Working in an international and intercultural context

## CONTENT

The course is divided into 4 parts including the participation of external speakers:
General introduction

1.Requirements for a circular economy and their application to the design and use of materials

2.Principles of the circular economy common to all families of materials

3.Circular economy & organic materials (polymers)
3.1. Polymer recycling processes
3.2. Petro & bio-based materials cycle

4.Circular economy & inorganic materials
4.1. Recycling processes for metal alloys and ceramics.
4.2. Glass cycle
4.3. Metallic materials cycle
4.4. Cycle and specificities of electronic components

## BIBLIOGRAPHY

## PRE-REQUISITES

* Knowledge of the process-structure-property relationships for the different materials

* Knowledge of the specificities of the different families of materials

# Sensors for environmental, biological and healthcare applications

## IDENTIFICATION

CODE : MT-5-S1-EC-CAPTENV
ECTS : 2.00

## HOURS

| | |
|---|---|
| Cours : | 14h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 14h |
| Travail personnel : | 0h |
| Total : | 14h |

## ASSESMENT METHOD

A 2h00 MCQ exam + DM FEM simulation

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. MALHAIRE Christophe : christophe.malhaire@insa-lyon.fr

M. SOUIFI Abdelkader : abdelkader.souifi@insa-lyon.fr

## AIMS

This course focuses on integrated sensors and for applications in the fields of environment and health. Developments in integrated sensor system technologies are also presented in the context of the development of digital solutions and the Internet of Things (IoT). These new approaches are of growing interest for real-time monitoring of environmental quality and/or for personalized medicine.

The course aims to:
1) To present the technological developments of integrated sensors in the context of diversification of functions on chips (¿more than Moore¿).
2) To illustrate sensor technologies by major fields of application: transport, connected cities, ¿consumer¿ electronics, environment, health.
3) To present the operation and integration processes of chemical and biological sensors for medical and/or environmental applications.
4) To present recent advances in these fields through a cycle of seminars for industrial speakers.

This EC falls under the teaching unit MT-5-UE-SDM-S1, Materials S1 and contributes to:

School skills in science for engineers:
A1 - Analyze a real or virtual system (or problem) (Level 1)
A2 - Use a model of a real or virtual system (Level 2)
A3 - Implement an experimental approach (Level 1)
A4 - Design a system that meets specifications (Level 1)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty (Level 2)

School skills in humanity, documentation and physical and sports education:
B2 - Work, learn, evolve independently (Level 2)
B3 - Interact with others, work in a team (Level 2)

Specialty-specific school skills:
C1 - Know and be able to establish the Structure-Property relationships of Materials (Level 1)
C2 - Identify and implement materials development methods (Level 1)
C3 - Apply materials (Level 2)
C4 - Modeling and predicting the behavior of materials (Level 2)

By mobilizing the following skills:
B1 - Self-evaluate one's own performance

## CONTENT

- Introduction: from the integrated sensor to micro-nano-bio-systems. Advantages, market, fields of application, development of micro-nano-bio-technologies.

- Presentation of the evolution of the main sensors integrated in CMOS technologies in the approach of diversification of functions on chips "more than Moore". Particular attention will be paid to environmental and biological sensor technologies and to BioMEMS for medical and environmental applications. The issues of energy recovery and management deployed for autonomous systems in the context of the Internet of Things (IoT) will also be addressed.

- A series of seminars for industrial speakers will present some recent advances in the fields of integrated biosensors and electronic nose technologies for medical and/or agri-food applications, and gas sensors for environmental quality control

## BIBLIOGRAPHY

- Microsensors: Principles and Applications, J.W. Gardner, Wiley, 1995

- Capteurs chimiques et biochimiques, N. Jaffrezic, C. Martelet, P. Clechet, Techniques de l¿ingénieur, 1994

- Environmental sensor network: a revolution in the earth system science? J.K. Hart et al., Earth Sci. Rev., 2006

- Sensor Systems for Environmental Monitoring, Ed. M. Campbell, Springer Nature, 1997

- Biological and Medical Sensor Technologies, Ed. K. Iniewski, CRC Press 2012

- Applications of commercial biosensors in clinical, food, environmental, and biothreat/biowarfare analyses, E.B. Bahadir & M.K. Sezgintürk, Biochem 2015

- Smart Sensors and Systems: Innovations for Medical, Environmental, and IoT Applications, C-M. Kyung and H. Yasuura, Springer Nature, 2017

## PRE-REQUISITES

Basic knowledge of sensors (3rd year sensor course, 4th year MEMS course) and micro-nano manufacturing technologies.

# Emerging technologies in advanced CMOS nanoelectronics

## IDENTIFICATION

CODE : MT-5-S1-EC-EMERTEC
ECTS : 1.00

## HOURS

| | |
|---|---|
| Cours : | 14h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 14h |
| Travail personnel : | 0h |
| Total : | 14h |

## ASSESMENT METHOD

Final exam on Table

## TEACHING AIDS

Lectures slides, On-line ressources (Moodle)

## TEACHING LANGUAGE

French
English

## CONTACT

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M. FOURMOND Erwann :
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## AIMS

This course will give students a synthetic and prospective overview of nano-fabrication processes for advanced CMOS circuits. In a first part, we present the evolution of the technological processes and functional materials to achieve an aggressive downscaling of devices toward the nanoscale while fulfilling the constraint of compatibility with CMOS technology. The major technological evolutions that have allowed a constant improvement of both computing performances and energy efficiency over the last few years wil also be presented.

In a second part, we illustrate the contributions of emerging technologies for the development of energy efficient embedded systems for Internet of Things (IoT) applications. More specifically, we will focus on the emerging concepts of information processing and storing (emerging memory and logic devices). After introducing the operating principles of these new devices, we show that they bring many opportunities to (i) drastically reduce the energy consumption of current computing architectures and (ii) enable new computing paradigms, such as neuromorphic computing for embedded-IA.

This EC MT-5-S1-EC-EMERTEC comes under the MT-5-S1-UE-SDM contributes to:

Specialty-specific school skills:
A1 - Analyze a real or virtual system (or problem) (Level 1)
A4 - Design a system that meets specifications (Level 1)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty (Level 2)
C1-Know and be able to establish the Structure-Property relationships of Materials (level 3)
C2-Identify and implement methods for developing materials (level 2)
C3-Apply materials (level 2)
C5-Innovate and research in materials (level 2)

By mobilizing the following skills:
B2-Work, learn, evolve independently
B5-Act responsibly in a complex world
B7- Working in an international and intercultural context

## CONTENT

- Advanced nano technologies: materials and processes for nanoCMOS transistors
- technologies for 3D integration
- Packaging: processes, challenges and key role
- Emerging Non-volatile memories for information storage
- Emerging logic devices based on few electron devices
- New computing paradigms based on Emerging technologies

This course will feature a 2h industrial seminar on advanced CMOS technologies

## BIBLIOGRAPHY

- M - W.-K. Chen, The VLSI Handbook, Second ed. CRC Press, 2007.

- S. A. Campbell, Engineering at the Micro- and Nanoscale, Third Edit. Oxford University Press, 2008.

- Y. Nishi and R. Doering, Handbook of Semiconductor Manufacturing Technology., vol. 2nd ed. CRC Press, 2008.

- R. Ismail, M.T. Ahmadi et S. Anwar, Advanced Nanoelectronics, CRC Press, 2016

- W.D. Brown et J.E. Brewer, Non-Volatile Semiconductor Memory Technology, IEEE Press, 2011

- R. Waser (Ed) Nanoelectronics and information technology, advanced electronic materials and novel devices, Wiley-VCH 2012

## PRE-REQUISITES

Physics of semiconductor materials and field effect transistors (MOSFET) (course MT-4

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

# Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

## Surface engineering

### IDENTIFICATION

CODE : MT-5-S1-EC-INGSURF
ECTS : 4.00

### HOURS

| | |
|---|---|
| Cours : | 28h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 28h |
| Travail personnel : | 0h |
| Total : | 28h |

### ASSESMENT METHOD

Written examination (2h)

### TEACHING AIDS

### TEACHING LANGUAGE

French

### CONTACT

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M. GERARD Jean-Francois :
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### AIMS

"This course proposes to give to the futur engineer an insight into the different ways able to improve the functional properties of the material surface".

Several solutions can be implemented to improve surface characteristics of a mechanical part: either to change the material, or to modify the nature of its surface. This course concerns the latter solution, and studies, on the one hand, the processes involved in the surface change, and, on the other hand, presents the consequences of this surface modification regarding part functionality. Surface modification results either from a bulk transformation (surface treatment) or from the deposition of an other material (coating). Properties linked to materials durability will be highlighted: resistance against wear, corrosion and oxidation.

### CONTENT

Introduction on Coatings and Surface Treatments (CST)

CST and surface functionality (concept of Surface Engineering) How to select ?

Treatments by structural transformation

Processes in liquid phase (Chemical, electrolytical deposition, elaboration by immersion, slurry coating)

Conversion, diffusion, organic layers

Processes in gazeous phase (Physical and Chemical Vapour deposition), Thermal spaying, coatings elaboration by high energy beam, cladding

### BIBLIOGRAPHY

L. Pawlowski, Dépôts Physiques : Techniques, microstructures et propriétés, 2003, Presses Polytechniques et Universitaires Romandes.

B. Normand, N. Pébère, C. Richard, M. Wéry, Prévention et lutte contre la corrosion, 2004, Presses Polytechniques et Universitaires Romandes.

Procédés électriques dans les traitements et revêtements de surface : DOPEE85, 1989, Electricité de France.

M. Cartier, Guide d'emploi des traitements de surface appliqués aux problèmes de frottement, 2000, Editions Tec et Doc.

### PRE-REQUISITES

The course entitled "Metal Manufacturing Processes" is recommended. Some knowledge concerning corrosion would be welcome.

# Numerical Methods for the Mechanics of Architectural Materials

## IDENTIFICATION

CODE : MT-5-S1-EC-MATARCHI
ECTS : 2.00

## HOURS

| | |
|---|---|
| Cours : | 14h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 14h |
| Travail personnel : | 0h |
| Total : | 14h |

## ASSESMENT METHOD

2 Finite element session reports

Written exam

## TEACHING AIDS

Course slides

## TEACHING LANGUAGE

French
English

## CONTACT

M. DOITRAND Aurelien :
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## AIMS

The objective of this course is to present the methods for estimating the mechanical properties (elasticity, fracture, crack propagation) of architectural materials: hybrid materials, with microstructure gradient, fiber or particle composites, porous materials, bio materials -inspired. The interfaces between constituents will be particularly studied.

This EC falls under the Teaching Unit MT-5-UE-SDM-S1 Materials S1 and contributes to the

School skills in science for engineers:
A2 - Use a model of a real or virtual system (Level 1)
A4 - Design a system that meets specifications (Level 1)
A5 - Process data (Level 1) )

Specialty-specific school skills:
C1 - Know and be able to establish the Structure-Property relationships of Materials (Level 1)
C2 - Identify and implement materials development methods (Level 1)
C4 - Modeling and predicting the behavior of materials (Level 1)
C5 - Innovate and research in materials (Level 2)

By mobilizing the following skills:
A1 - Analyze a real or virtual system (or problem)
A6 - Communicate a scientific analysis/approach with scenarios adapted to their specialty
B2 - Work, learn, evolve independently
C3 - Apply materials

By allowing the student to work and be assessed on the following knowledge:

- know the specific characteristics of architectural materials

- know the homogenization methods used in the mechanics of materials

- know the different techniques for calculating the elastic properties of heterogeneous materials

- know the general characteristics of natural and artificial structural materials: anisotropy, multi-scale architecture, reinforcement mechanisms.

By allowing the student to work and be assessed on the following abilities:

- To be able to describe the load transfer mechanism at an interface between components and to explain the resistance to crack propagation in architectural materials,

- Be able to determine the elastic characteristics of heterogeneous architectural materials.

## CONTENT

- Introduction aux matériaux architecturés

- Homogénéisation (propriétés élastiques et à rupture, implémentation par élément finis (Abaqus)

- Le rôle des interfaces dans les matériaux architecturés (application éléments finis)

## BIBLIOGRAPHY

M. Ashby & Y. Brechet, Acta Mater. 51 (2003) 5801.

M. Ashby, Sci Mat. 68 (2013)

# Durability of polymers

## IDENTIFICATION

CODE : MT-5-S1-EC-DURPOLY
ECTS : 2.00

## HOURS

| | |
|---|---|
| Cours : | 14h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 14h |
| Travail personnel : | 0h |
| Total : | 14h |

## ASSESMENT METHOD

Oral presentation of about 15 minutes followed by questions on a proposed topic, related to the course with support + a summary sheet on the same subject, in A4 format.

## TEACHING AIDS

Documents

## TEACHING LANGUAGE

French

## CONTACT

M. FLEURY Etienne :
etienne.fleury@insa-lyon.fr

## AIMS

This module aims to present the problem of ageing in polymeric materials. It aims to allow the student to understand:

- the different modes of ageing depending on the nature of the material (structures, polymer chemistry, presence of additives, crystallinity...) and its conditions of use (mechanical constraints, temperature, oxygen, solvent...).

- the impact of ageing on the physico-chemical properties of polymers,

- the modes of action of the different stabilizers,

- the methodologies of evaluation of the ageing of polymers,

- A reflection on the predictive methods of polymer ageing.

This EC MT-5-S1-EC-DURPOLY falls under the Teaching Unit MT-5-S1-UE-SDM Engineering Science Semester 1 and contributes to:

School skills in science for engineers:
A5 - Process data (Level 2)
B2 - Work, learn, evolve independently (Level 2)

Specialty-specific school skills:
C1 - Knowing and being able to establish the Structure-Property relationships of Materials
(Level 3)
C2 - Identify and implement materials development methods (Level 2)

By mobilizing the following skills:
A1 - Analyze a real or virtual system (or problem) (Level 2)
A2 - Use a model of a real or virtual system (Level 2)
A4 - Design a system that meets specifications (Level 2)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty (Level 3)
C5 - Innovate and research in materials (Level 2)

By allowing the student to work and be assessed on the following knowledge:
- know the main families of synthetic and natural polymers,
- know the main modes of aging of synthetic and natural polymer materials,
- know the main analytical methods for characterizing the aging of polymer materials
- recognize the impact of aging on the usage properties of polymeric materials
- recognize the impact of aging on the physico-chemical properties of polymer materials,

By allowing the student to work and be assessed on the following abilities:

- be able to make the link between the structure of a polymer, its properties and its ability to age under various conditions of use,
- be able to explain the stabilization strategy of a polymer material with respect to thermo-oxidation, photo-oxidation,
- be able to predict the life of a polymer material,

## CONTENT

I. Introduction

II. Physical Ageing

III. Chemical ageing

III.1 Generalities on the mode of degradation
III.2 Impact on physical-chemical properties
III.3 Different types of aging classified according to the external cause

IV. Lifetime prediction

V. External stakeholders
V.1 Evaluation of the photodegradability of polymeric materials
V.2 Ageing of silicones

## BIBLIOGRAPHY

[1] Handbook of weathering, 2nd edition, G.Wypych, Chem. Tech. Publishing (1995)

[2] Chimie organique, J.P.Mercier, P.Godard, Presses Polytechniques et Universitaires

Romandes (1995)

[3] Techniques de l'ingénieur : Vieillissement physique (AM1/A3150), Vieillissement chimique
(AM1/A3151), Vieillissement dû à l'eau (AM1/A3165), Dégradation thermique (AM2/ AM3173

## PRE-REQUISITES

Advanced knowledge (M4 Level) of polymer chemistry and physical chemistry

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

## Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Materials for photonics

### IDENTIFICATION

CODE : MT-5-S1-EC-MATPHOT
ECTS : 2.00

### HOURS

| | |
|---|---|
| Cours : | 14h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 14h |
| Travail personnel : | 0h |
| Total : | 14h |

### ASSESMENT METHOD

20 min oral presentation of a group investigation on a technological problem

### TEACHING AIDS

Lecture slides on the Moodle platform

### TEACHING LANGUAGE

French
English

### CONTACT

M. MASENELLI Bruno :
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## AIMS

Being familiar with the nanomaterials and devices based on them for photonic systems (active emitters, passive receptors, amplifiers¿) and being able to select the appropriate material and device depending on the foreseen application and function.

This EC falls under the Teaching Unit MT-5-UE-SDM-S1, Materials S1 and contributes to:

School skills in science for engineers:
A1- Analyze a real or virtual system (or problem), at a medium level
A2- Use a model of a real or virtual system, at a medium level
A4- Design a system that meets specifications, at a minimum level
A6- Communicate an analysis or a scientific approach with scenarios adapted to their specialty, at a medium level

Specialty-specific school skills:
C1 - Knowing and being able to establish the Structure-Property relationships of Materials
(level 3)
C3 - Apply materials (level 2)
C4 - Modeling and predicting the behavior of materials (level 2)

By mobilizing the following skills:
B2 - Work, learn, evolve independently
B3 - Interact with others, work in a team

## CONTENT

1- quantum confinement
1.1- confinement effects in 2 D, 1 D and 0 D on Eg and DOS
1.2 - application to Single Photon Sources (HBT, application to quantum cryptography)

2- Material classes: IV, III-V, II-VI semiconductors, perovskites and organic semiconductors

3- light emitters
3.1- LED
Example of application to indoor lighting, vision (flat panel displays, TV, VR helmets)
3.2- Laser
Laser architecture: lasing condition, VCSEL, Bragg reflectors, photonic crystals
Example of application : telecom

4- light detectors
APD and SPAD
Example of application : LiDAR

5- light amplifier
Plasmonic antennas and amplifiers (visible, IR) and notion of metamaterials

## BIBLIOGRAPHY

- S.V. GAPONENKO, Introduction to Nanophotonics, Ed. Cambridge University Press

- V.V. MITIN, D. I. Sementsov, N. Z. Vagidov, Quantum Mechanics for Nanostructures, Ed. Cambridge University Press

- H. MATHIEU : Physique des Composants Electroniques. Ed. Dunod

- P. BHATTACHARYA : Semiconductor optoelectronic devices. Ed. Prentice Hall (1994)

- E. ROSENCHER, B. WINTER : Optoélectronique. Ed. Dunod

- Z. TOFFANO : Optoélectronique : Composants Photoniques et Fibres Optiques - Ellipses

- A. YARIV : Optical Electronics in Modern Telecommunications - Ed. Oxford University

- J. SINGH : Semiconductor Optoelectronics : Physics and Technology - Ed. Mac Grow Hill

- J. SINGH : Electronic and Optoelectronic properties of semi-conductor structures - Ed. Cambridge University Press

## PRE-REQUISITES

## IDENTIFICATION

CODE : MT-5-S1-EC-ECIU
ECTS :

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 0h |
| Travail personnel : | 0h |
| Total : | 0h |

## ASSESMENT METHOD

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

## AIMS

On-demand courses

## CONTENT

## BIBLIOGRAPHY

## PRE-REQUISITES

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

**Ingénieur, spécialité matériaux**

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Material Processing

## IDENTIFICATION

CODE : MT-5-S1-EC-MEFMAT
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 28h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 28h |
| Travail personnel : | 0h |
| Total : | 28h |

## ASSESMENT METHOD

30 minute examination in the form of a questionnaire

## TEACHING AIDS

Course slides

## TEACHING LANGUAGE

French

## CONTACT

M. KLEBER Xavier :
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M. LORTIE Frédéric :
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## AIMS

The objective of this course is to present the different manufacturing processes of metallic and polymer materials and the existing relationships between the properties of these materials, their processability and the main process parameters.

This EC falls under the Teaching Unit MT-5-UE-SDM-S1 Materials S1 and contributes to:

School skills in science for engineers:
A1 - Analyze a real or virtual system (or problem) (Level 1)
A2 - Use a model of a real or virtual system (Level 2)
A3 - Implement an experimental approach (Level 2)
A4 - Design a system that meets specifications (Level 1)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty (Level 1)

School competencies in humanity:
B3 - Interact with others, work in a team (level 1)
B4 - Be creative, innovate, undertake (level 2)

Specialty-specific school skills:
C2 - Identify and implement materials development methods (level 3)
C3 - Apply materials (level 2)
C4 - Modeling and predicting the behavior of materials (level 1)
C5 - Innovate and research in materials (level 2)

By mobilizing the following skills:
C1 - Knowing and being able to establish the Structure-Property relationships of Materials
C4 - Modeling and predicting the behavior of materials
B2 - Work, learn, evolve independently
B7 - Working in an international and intercultural context

by allowing the student to work and be assessed on the following knowledge and abilities:
- know the classic processes for transforming metallic materials, polymers and their composites
- know some process modeling approaches,
- know the technical limits of these processes
- be able to relate the properties of a metallic or polymer material to its suitability for transformation
- be able to explain the operation and identify the key parameters of a given process,
- be able to choose an implementation process according to different technological and industrial constraints
- be able to optimize the parameters of a transformation process for a metallic, polymer or composite material,

## CONTENT

For the Metallic Materials part:
- Introduction to the choice of materials/processes
- Foundry processes and solidification phenomenon
- Powder metallurgy (sintering, SPS)
- Plastic forming and formability: volume forming (forging, extrusion, rolling), sheet metal forming (stamping)
- Machining: non-conventional processes (electrochemical, electro erosion), cutting tools
- Assembly and welding: bonding, brazing, autogenous welding

For the Polymer Materials part:
- General information on thermoplastic extrusion
- Single screw extrusion modelling
- Injection of thermoplastics
- Conventional thermoplastic processing processes
- Precursors and half-products for preparing polymer-based composites
- Liquid Closed Molding (LCM) process
- Conventional processes of polymer-based composites
- Latest trends in polymer processing

## BIBLIOGRAPHY

- Manufacturing Processes for Engineering Materials S. KALPAKJIAN [Addison - Wesley Ed. (1985)]

- Materials Selection in Mechanical Design M.D. ASHBY [Pergamon Press (1994)]

- Principles of metal manufacturing processes J. BEDDOES, M.J. BIBBY [Arnold (1999)]

- Industrialisation des Produits Mécaniques (3) C. MARTY, J.M. LINARES [Hermès (1999)]

-« La mise en forme des matières plastiques », J.F. Agassant, P. Avenas, J.P. Sergent, B. Vergnes, M. Vincent, Lavoisier (Tec et Doc), Paris (1996)

- « Polymer Processing, Principles and Modeling », J.F. Agassant, P. Avenas, Ph. Sergent, P. Carreau, Hanser Publishers, Munich (1991)

## PRE-REQUISITES

4SGM Lecture: Mechanical Behavior of Materials
4SGM Lecture: Metallurgy
4SGM Lecture: Polymers

Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Materials for health

## IDENTIFICATION

CODE : MT-5-S1-EC-MSANTE
ECTS : 4.00

## HOURS

| | |
|---|---|
| Cours : | 28h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 28h |
| Travail personnel : | 0h |
| Total : | 28h |

## ASSESMENT METHOD

Different topics will be proposed by teachers: project by student group

Students will define the context by using the course content and will select relevant publications relating to the chosen topic: preparation of a short report per student group (4 or 5 students as a function of the total numbers of auditors)

## TEACHING AIDS

Detailed power point available on the MOODLE platform, and delivery of a printed version for each student

## TEACHING LANGUAGE

French

## CONTACT

MME CHARLOT Aurelia :
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M. CHEVALIER Jerome :
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## AIMS

General introduction dealing with biomaterials. The concepts of biocompatibility and bioactivity will be discussed, since biomaterials imply the notions of contacts with tissues. The main families of materials will be described, with their assets and limitations to be used in the health field. Various applications scopes will be reviewed.

Then, the course will mainly state ceramic and polymer biomaterials, and additional examples will concern metallic biomaterials and medical dispositive including sensors, biochips¿

Presentations from external staff from INSA will be conducted (industrials, engineers, ¿).

This EC falls under the Teaching Unit MT-5-UE-SDM-S1 Materials S1 and contributes to:

School skills in science for engineers:
A4 - Design a system that meets specifications (Level 2)

School skills in humanity, documentation and physical and sports education:
B3 - Interact with others, work in a team (Level 3)
B4 - Be creative, innovate, undertake (Level M)

Specialty-specific school skills:
C1 - Knowing and being able to establish the Structure-Property relationships of Materials (Level 3)
C2 - Identify and implement materials development methods (Level 2)
C3 - Apply materials (Level 3)
C4 - Modeling and predicting the behavior of materials (Level 2)

By mobilizing the following skills:
A1 - Analyze a real or virtual system (or problem) (Level 2)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty (Level 2)
C5 - Innovate and research in materials

By allowing the student to work and be assessed on the following knowledge:

- know what is meant by the field of encapsulation, vectorization and release of bioactive molecules

- know some chemical and physical approaches to the development of (nano and micro) polymer particles, and (chemical and physical) polymer gels: the objective is to understand the concept

- know some major families of synthetic and natural polymers that can be used in the field of bioactive molecule release in this field: how are they synthesized or obtained? what are their chemical, physico-chemical properties in relation to the fields of application

By allowing the student to work and be assessed on the following abilities:

- To be able to distinguish between synthetic polymers and polymers of natural origin and to know their main differences

- Be able to describe the main chemical routes allowing the production of synthetic polymers used in the field of the release of bioactive molecules

- Be able to describe the renewable sources leading to the natural polymers used in the field of biomaterials

## CONTENT

- General introduction: interests and challenges of biomaterials

- Concepts of biofunctionality, biocompatibility, bioactivity

- Ceramic biomaterials and their applications:

a) Example of evolution of biomaterials for orthopedic surgery
b) Reparation and bone repair
c) Dental restoration and implantology

- Polymer biomaterials and their applications:

a) Example of drug delivery

b) Chemical and physico-chemical processes of elaboration
c) Families of synthetic and natural polymers for biomaterials

- Intervention : « Future of metallic biomaterials »

- Dispositives/biochips/sensors

- Intervention concerning the use of biomaterials for dental implantology (practicioner)

- Intervention dealing with additive fabrication and visit of a technical platform (from 3D printing to bio-printing)

- Industrial intervention on the use of natural polymer for filling skin

## BIBLIOGRAPHY

Bibliographic resources will be provided throughout the course.

## PRE-REQUISITES

General knowledge in materials science

# Polymer nanomaterials

## IDENTIFICATION

CODE : MT-5-S1-EC-NANOPOLY
ECTS : 2.00

## HOURS

| | |
|---|---|
| Cours : | 14h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 14h |
| Travail personnel : | 0h |
| Total : | 14h |

## ASSESMENT METHOD

Exam in the form of a documentary research on a pre-defined subject with the submission of two deliverables: a 4-column/2-page summary with template (format: concise and precise note) + oral presentation in front of the whole group of students (15').
This exam will allow the student to repeat the basic notions presented in the body of the course on a particular case of nanomaterials by using the design, characterization and situation approach developed in the course. The ability to synthesize will thus be emphasized.

## TEACHING AIDS

Booklet with reproductions of the presented slides (in English) and electronic version of the slides available on Moodle.

## TEACHING LANGUAGE

French

## CONTACT

M. GERARD Jean-Francois :
jean-francois.gerard@insa-lyon.fr

M. BAEZA Guilhem :
guilhem.baeza@insa-lyon.fr

## AIMS

- To know and understand the preparation mechanisms (synthesis processes, formulation and implementation) of polymer-based materials organized at the nanoscopic lengthscale (nanocomposites, block copolymers and supramolecular networks).

- Understand and know how to characterize the morphologies of polymer nanomaterials in relation to their physical behaviors and their industrial applications

This EC falls under the Teaching Unit MTM-5-UE-SDM S1, Materials S1, and contributes to:

School skills in science for engineers:
A4 - Design a system that meets specifications (Level 2)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specificity (Level 2)
B2 - Work, learn, evolve independently (Level 1)
B3 - Interact with others, work in a team (Level 2)
B4 - Be creative, innovate, undertake (Level 1)

Specialty-specific school skills:
C1 - Knowing and being able to establish the Structure-Property relationships of Materials (Level 3)
C2 - Identify and implement materials development methods (Level 3)
C3 - Apply materials (Level 2)
C4 - Modeling and predicting the behavior of materials (Level 2)

By mobilizing the following skills:
A1- Analyze a real or virtual system (or problem) A2 ¿ Develop an experimental approach (Level 2)
A2- Use a real or virtual system model

## CONTENT

1.- INTRODUCTION
1.1.- Nanotechs & Economy
1.2.- Why nanoscale for polymer-based nanomaterials?
1.3.- Definitions, vocabulary and Nomenclature relative to nanomaterials.

2.- STRATEGIES AND PROCESSES FOR DESIGNING NANOSTRUCTURED POLYMER MATERIALS
2.1.- Introduction
2.2.- Nanomaterials designed from self-assembling processes
. Semi-crystalline polymers as nanomaterials
. Liquid crystal polymers
. Supramolecular nanomaterials from self-assembling of organic molecules
. Block copolymers self-assembling
Illustrations for BCP-based nanomaterials for nanoelectronics, photonic, etc applications
2.3.- Nanostructuration from nano/microphase separation process
. Nanoblends
. Hybrid organic-inorganic nanomaterials
Illustrations for coatings and composites applications
2.4.- Nanomaterials from pre-formed nano-objects (nanocomposites)
. Nanomaterials from pre-formed organic or O/I nano-objects: dendrimers, oxo-clusters
. Nanofillers: Preparation, surface properties, dispersion in a polymer matrix
- Carbon-based nano-objects : carbon black, fullerenes, nanotubes, and graphene
- Silicon-based nano-objects: types of silica and surface modification, clays, etc
- Others
Illustrations for nanocomposites applications: gas barrier, electrical conductivity, fire Resistance, etc applications

3.- CARACTERISATION OF THE STRUCTURE-PROPERTIES RELATIONSHIP
3.1. Structural analysis
. Direct space : electronic microscopy and atomic force microscopy applied on nanocomposites and block copolymers
. Reciprocal space : introduction to small angle scattering techniques (principle, devices) and application to ¿real¿ materials.

3.2. Mechanical characterization
. Glassy state (segmental relaxation and impact of the nanostructuration)
. Rubbery state (reinforcement, viscoelasticity, introduction to physical models). Effect of the mechanical percolation.
. Liquid state, polymer solutions and colloidal suspensions

3.3. Other properties
. Electrical characterisation through bradband dielectric spectroscopy (conductivity, ionic

mobility, multiscale relaxations of polymers). Application to the case of all-solid batteries. Effects of electrical percolation.
. Magnetic properties of nanocomposites. Application to the case of hyperthermia and actuators.
. Gaz permeability (permeation tests), gaz filtration
. Fire resistance
. Optical properties (birefringence and photoelasticimetry)

4.- CONCLUSIONS ¿ WHAT TO REMEMBER ?
Preparation, processes associated with their implementation, morphologies, properties and performances.

## BIBLIOGRAPHY


- Nanomaterials and Polymer Nanocomposites: Raw Materials to Applications 1st Ed., N. Karak, Elsevier Edts, 2018. ISBN: 9780128146163

- Polymer Science and Nanotechnology: Fundamentals and Applications 1st Ed., R. Narain, Elsevier Edts, 2020. ISBN: 978-0128168066

- Fabrication and Application of Nanomaterials, 1st Ed., S. Bandyopadhyay. McGraw-Hill Educatiion Edts, 2019. ISBN: 9781260132236

-Polymer Physics, (OUP Oxford (26 Juin 2003), M. Rubinstein and R. Colby


## PRE-REQUISITES

In-depth knowledge of the physics of matter and polymer materials, physical chemistry of polymers, structure-property relationships of polymer materials. Basic knowledge about characterization techniques.

# Material design

## IDENTIFICATION

CODE : MT-5-S1-EC-DESIGN
ECTS : 0.00

## HOURS

| | |
|---|---|
| Cours : | 14h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 14h |
| Travail personnel : | 0h |
| Total : | 14h |

## ASSESMENT METHOD

Group project on a materials design issue

## TEACHING AIDS

courses slides

## TEACHING LANGUAGE

French

## CONTACT

M. LORTIE Frédéric :
frederic.lortie@insa-lyon.fr

## AIMS

The objective of this course is to introduce the Design Thinking approach, applied here to materials

This EC falls under the Teaching Unit MT-5-UE-SDM-S1 Materials and contributes to:

School skills in science for engineers:
A4 - Design a system that meets specifications (Level 2)

School competencies in humanity:
B3 - Interact with others, work in a team (Level 1)
B4 - Be creative, innovate, undertake (Level 3)
B7 - Working in an international and intercultural context (Level 2)

Specialty-specific school skills:
C3 - Apply materials (Level 3)

By mobilizing the following skills:
C3 - Apply materials (Level 3)

By allowing the student to work and be assessed on the following knowledge:
- know the definition and scope of industrial design
- know the key stages in the historical evolution of industrial design
- know the main lines of the industrial creation process
- be able to communicate with a designer
- be able to integrate the design dimension into the development of a product or technology

## CONTENT

- Introduction: design in everyday life

- Cultural and historical dimensions of design

- International and future dimensions of design

- The ¿Design Thinking¿ approach

## BIBLIOGRAPHY

Materials and Design: The Art and Science of Material Selection in Product Design¿, Michael Ashby, Kara Johnson, Butterworth-Heinemann publications, 1st edition, (2002)

## PRE-REQUISITES

Basic knowledge on materials sciences

# Photovoltaic Energy

## IDENTIFICATION

CODE : MT-5-S1-EC-PHOTOV
ECTS : 2.00

## HOURS

| | |
|---|---|
| Cours : | 14h |
| TD : | 0h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 14h |
| Travail personnel : | 0h |
| Total : | 14h |

## ASSESMENT METHOD

Written exam

## TEACHING AIDS

Course slides available on moodle

## TEACHING LANGUAGE

French

## CONTACT

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## AIMS

The objective is to give students the physical bases of the quantum conversion of solar radiation to lead them to the design of a photovoltaic system, starting from the material to the component, taking into account economic and environmental constraints.

This EC falls under the Teaching Unit MT-5-UE-SDM-S1 Materials S1 and contributes to:

School skills in science for engineers:
A1 - Analyze a real or virtual system (or problem) (Level 2)
A3 - Implement an experimental approach (Level 1)
A4 - Design a system that meets specifications (Level 2)
A6 - Communicate an analysis or a scientific approach with scenarios adapted to their specialty (Level 1)

Specialty-specific school skills:
C1 - Know and be able to establish the Structure-Property relationships of Materials (Level 2)
C2 - Identify and implement materials development methods (Level 1)
C3 - Apply materials (Level 2)
C4 - Modeling and predicting the behavior of materials (Level 2)

By mobilizing the following skills:
A1 - Analyze a real or virtual system (or problem) (Level 2)
A2 - Use a model of a real or virtual system

## CONTENT

Solar field

Solar Cell Physics: Photovoltaic Conversion, Advanced Silicon solar Cells, Tandem Structures

Thin film cells: a-Si, CIGS, CdTe, III-V

New materials (Organic, perovskites)

PV plant

## BIBLIOGRAPHY

M.A GREEN, Silicon solar cells, Cent. For Photovolt. Dev. And Sys. (UNSW)

S.M SZE, Semiconductor devices - Physics and technology, Ed. J. wiley
https://www.pvlighthouse.com.au

## PRE-REQUISITES

Base of Solid State Physics, Physics and Technology of Semiconductor Materials

# Final year project PFE

## IDENTIFICATION

CODE : MT-5-S1-EC-PFE
ECTS : 15.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 12h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 12h |
| Travail personnel : | 0h |
| Total : | 12h |

## ASSESMENT METHOD

## TEACHING AIDS

## TEACHING LANGUAGE

French
English

## CONTACT

M. MANDORLO Fabien :
fabien.mandorlo@insa-lyon.fr

## AIMS

The students will experiment research in a lob of the Materials Science Department or innovative work in relation with a company accompanied by a supervisor. Every student will have to write a report and to give an oral presentation.

## CONTENT

## BIBLIOGRAPHY

## PRE-REQUISITES

# Project Medium-term

## IDENTIFICATION

CODE : MT-5-S1-EC-PROMSD
ECTS : 2.5

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 44h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 44h |
| Travail personnel : | 0h |
| Total : | 44h |

## ASSESMENT METHOD

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. KLEBER Xavier :
xavier.kleber@insa-lyon.fr

## AIMS

- Know how to lead a project of average duration in Science of Materials, following specifications established by a teacher.

- Know how to realize and analyze conventional tests of mechanical or physico-chemical behavior of materials and/or process a type of material (ceramic, composite, metal).

- Give relevant information to another group of students, who were not involved in the project.

- Present the results of a project for which the student was not involved for the experimental part.

## CONTENT

- 4 days dedicated to the experimental part of the project,

- 1 1/2 day dediated to the exchange of informations between groups of strudents,

-- 1 day dedicated to the oral examination

## BIBLIOGRAPHY

## PRE-REQUISITES

Basic knowledge in Materials Science.

# Project Medium-term

## IDENTIFICATION

CODE : MT-5-S1-EC-PROPPF
ECTS : 2.50

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 44h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 44h |
| Travail personnel : | 0h |
| Total : | 44h |

## ASSESMENT METHOD

Results obtained by students and their interpretation are presented both as a written report and as an oral communication.

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

M. LORTIE Frédéric :
frederic.lortie@insa-lyon.fr

## AIMS

To be able to manage an engineer team project
Practice of the polymer materials and composites knowledge gained in the two previous years in the department. Eight mini-projects are proposed for teams of two or three students

## CONTENT

Examples of proposed topics
- Formulation and processing of industrial polymer materials (PE-PS-PS- HIPS PVC "compound")- Thermo-mechanical history, influence on the microstructure and on mechanical properties - packaging applications.
- Elaboration and compatibilization of polymer blends. Extrusion and injection processing- recycling applications.
- Thermosetting materials elaboration: TTT - diagram ¿kinetic modelling, structural adhesive applications
- RTM process of thermoset based composites - in situ monitoring of the flow and polymerisation - mechanical properties of the final materials.- application to structural materials for automotive and aeronautic transports.

## BIBLIOGRAPHY

## PRE-REQUISITES

the two previous years dealing with polymer material sciences

# Project Medium-term

## IDENTIFICATION

CODE : MT-5-S1-EC-PROSCM1
ECTS : 2.50

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 44h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 44h |
| Travail personnel : | 0h |
| Total : | 44h |

## ASSESMENT METHOD

A synthesis report group on each subject

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

## AIMS

Knowledge of the environment of the industry of micro-electronics, from the simulation to the development including the tools for characterization.
Main characterization techniques of semiconductors materials and electronic devices. Realisation of microelectronic devices and circuits in clean room..

## CONTENT

- Diffusion length measurements with spectral response
- Hall effect characterization
- Semiconductor characterization by photoluminescence process
- Characterization of defects by the DLTS technique
- Electrical characterization of MOS structures
- Characterization of optical fiber connections with reflectometry and presentation of optical fiber sensors
- Study of the optical pumping of a laser Nd-YAG by laser diode
- Simulation on SPICE and CADENCE
- MOS technology processing, realised in clean room
- Use of a SIMS CAMECA analyzer

## BIBLIOGRAPHY

[1] D.K SCHROEDER, Semi Conductor Materials Devices Characterization, Ed. John Wiley (1990)
[2] M.A GREEN, silicon solar cells, Cent. For Photovolt. Dev. And Sys (UNSW) (1995)
[3]S. M. SZE, Semiconductor devices - Physics and technology, Ed. J Wiley (1985)

## PRE-REQUISITES

Ingénieur, spécialité matériaux

Domaine Scientifique de la DOUA
20 Avenue Albert Einstein - 69100 VILLEURBANNE

# Project Medium-term

## IDENTIFICATION

CODE : MT-5-S1-EC-PROSCM2
ECTS : 2.50

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 0h |
| TP : | 44h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 44h |
| Travail personnel : | 0h |
| Total : | 44h |

## ASSESMENT METHOD

A synthesis report group on each subject

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

## AIMS

Knowledge of the environment of the industry of micro-electronics, from the simulation to the development including the tools for characterization.
Main characterization techniques of semiconductors materials and electronic devices. Realisation of microelectronic devices and circuits in clean room..

## CONTENT

- Diffusion length measurements with spectral response
- Hall effect characterization
- Semiconductor characterization by photoluminescence process
- Characterization of defects by the DLTS technique
- Electrical characterization of MOS structures
- Characterization of optical fiber connections with reflectometry and presentation of optical fiber sensors
- Study of the optical pumping of a laser Nd-YAG by laser diode
- Simulation on SPICE and CADENCE
- MOS technology processing, realised in clean room
- Use of a SIMS CAMECA analyzer

## BIBLIOGRAPHY

[1] D.K SCHROEDER, Semi Conductor Materials Devices Characterization, Ed. John Wiley (1990)
[2] M.A GREEN, silicon solar cells, Cent. For Photovolt. Dev. And Sys (UNSW) (1995)
[3]S. M. SZE, Semiconductor devices - Physics and technology, Ed. J Wiley (1985)

## PRE-REQUISITES

## IDENTIFICATION

CODE : MT-5-S2-EC-STAGE
ECTS : 30.00

## HOURS

| | |
|---|---|
| Cours : | 0h |
| TD : | 770h |
| TP : | 0h |
| Projet : | 0h |
| Evaluation : | 0h |
| Face à face pédagogique : | 770h |
| Travail personnel : | 0h |
| Total : | 770h |

## ASSESMENT METHOD

The students have to defend their work in the presence of an instructor from the INSA who supervises the work the training. They have also to write a report which describes th essentials of their work. The final evaluation is established by the industrial supervisor and the instructor.

## TEACHING AIDS

## TEACHING LANGUAGE

French

## CONTACT

## AIMS

AN industrial training period (4 to 6 months) is included in the engineering degree. This permits to the students to apply what they have learnt in real industrial conditions. They must effectively carry out the project that is given by the company.

This training takes place in France or in a foreign country, in small and medium size industries, or in large compagnies and research centers (THOMSON, ALCAN, RHODIA, ARCELOR, MOTOROLA, ST MICROELECTRONICS, ALCATEL, CEA, CERN, PSA, EADS, RENAULT, TOTAL).

## CONTENT

## BIBLIOGRAPHY

## PRE-REQUISITES