MaMaSELF at UR1

As MaMaSELF student registered at UR1 you will be enrolled at the

Material Sciences Master

either attached to the Physics Institute or to the Chemistry Institute

FIRST YEAR (M1)

The first Mamaself year (M1) at UR1 serves as a consolidation of the basis in Quantum Mechanics, Crystallography, Experimental Physics and Chemistry, Spectroscopy, as well as to start the new fields that will lead the students to their second year and Master Thesis, like neutron and synchrotron spectroscopy, nanomaterials, metals and electrochemistry.

A detailed list of the subjects that can be found for the M1 is detailed below:

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FIRST SEMESTER

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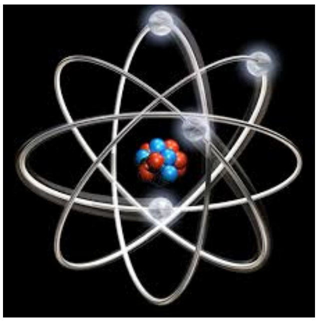
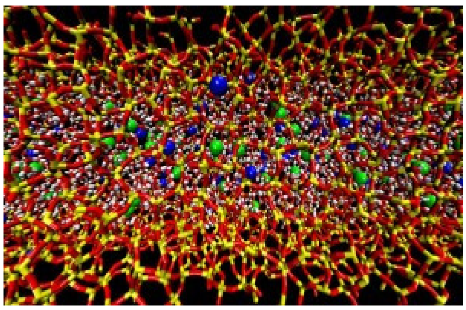


UE 1: Quantum Mechanics of atoms, Molecules & Solid State

Objectives: Obtain and consolidate a basic knowledge of Quantum Mechanics (QM) and their applications to atoms, molecules and the electronic structure of the solid state. The course consists of three parts, dealing successively with the fundamental aspects of QM, with atoms (monoelectronic and multielectronic) and finally with the chemical bond. Lessons will be made largely in the form of tutorials.

UE 2 : Crystallography

Objectives: Introduction to crystallography, resolution crystal structures, presentation of the techniques used nowadays at synchrotron and neutron sources.



- Symmetry and vector field: Reminders on symmetry; elements of point symmetries; translational symmetry (concept of lattice, change of basis, screw axes, glide planes)

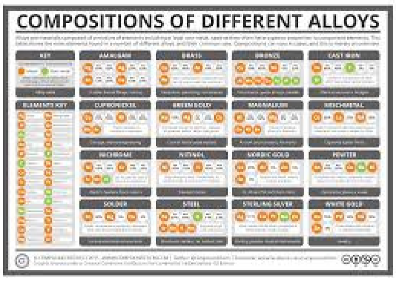
- Scattering by a periodic system: introduction to the reciprocal lattice; lattice structure factor; atomic scattering factor; Bragg's law; Laue condition; Miller indices; Ewald construction; Brillouin zone, Wigner-Seitz cell

- Diffusion length; Debye-Waller factor; anomalous scattering; applications of the Ewald sphere; Friedel law and non-centrosymmetric structures.

- Resolution of structures: data acquisition; data correction; Patterson method; direct methods; modulated structures; magnetic structures; twinned crystals; refinement (on computer).

- Equipment (X-ray and neutron sources); monochromators; detectors; beam definition and resolution; alignment and orientation of a crystal on a diffractometer; proper data collection.

UE 3 : Metals and Alloys



Objectives: To acquire a basic knowledge of common metals and alloys. The course is divided into two parts, dealing successively with crystallochemical and then with metallurgical aspects of metals and alloys.

The first part of the course includes a detailed description of the basic properties (electronic, structural, physical) of metals and alloys. The key concepts of the study of phase diagrams are discussed through typical examples, showing the mechanisms of substitution, phase transformations and thermal stability. A phenomenological description of the magnetic behavior of representative compounds is also given. In more details:

The second part of the course is about a general introduction to metallurgy. It addresses four major aspects such as solidification, phase transformations, mechanical properties and heat treatment. The evolution of the behavior of mechanical properties after heat treatment, which helps defining the qualities expected for metals & alloys, is explained.

UE 4 : Laboratory of Chemistry

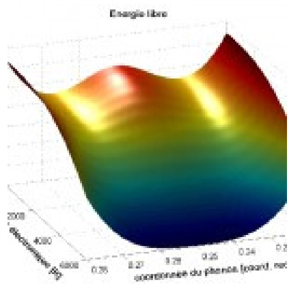
Objectives: To develop the necessary practical skills for research activities and to complete the theoretical knowledge acquired in other UE by laboratory experiments.

These laboratory classes are based on the preparation and physico-chemical characterization of materials of technological interest. The student has at its disposal the ad-hoc literature and a brief description of the manipulations to be performed. This approach leaves a lot of autonomy to students and seeks for their critical thinking, curiosity and organization abilities. All synthetic routes to solid state chemistry are used: solid route, crystallization, gels and glasses preparation. The materials to be prepared and characterized can be superconducting oxides, photo- and thermo-chrome compounds, luminescent materials, phosphorescent materials, intercalation materials, a photo-electrochemical cell, biomaterials. Such compounds, after their preparation, are then analyzed by traditional methods of chemistry: X-ray diffraction, thermogravimetric analysis, chemical assay, UV-visible and IR absorption spectroscopy. Magnetic, levitation and conduction measurements are also performed.

UE 5 : Laboratory of Physics I

Objectives: To develop the necessary practical skills for research activities and to complete the theoretical knowledge acquired in other UE by laboratory experiments.

These laboratory classes are based on the physical characterization of materials of technological interest. Almost all the basic techniques are presented whose theoretical background has been developed in other 'physics' UE: from optical measurements to electric measurements, from calorimetric measurements to magnetic measurements.



UE 6: Materials resistance – Numerical simulations

Objective : Knowledge of materials resistance is taking an increasingly important part in applications in material science. It is therefore necessary, for a student getting a master degree in materials science, to acquire a good knowledge of this area and the associated numerical resolution methods. The use of state-of-the-art software allows, with a minimum learning-time, to adopt the full power of the numerical methods and the most powerful graphics.

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SECOND SEMESTER

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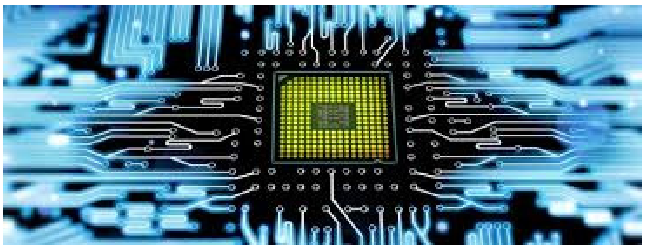
UE 7: Phase transitions and Semiconductors

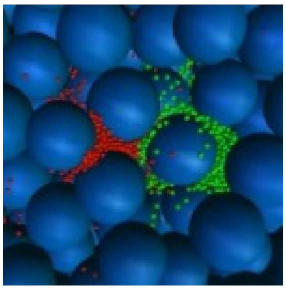


Objective : To obtain fundamental knowledge about the properties of semiconductors and magnetism in matter

This UE consists of two parts. In the first part phase transitions of matter are mainly discussed (magnetic, charge, order parameters, Landau's theory), together with other related aspects. In the second part more specific aspects of semiconductors are discussed: the concept of band-gap, hole- and electron-doping, charge-carrier transport, operating devices (pn diode junction, field effect transistor, spin transport and molecular conduction).

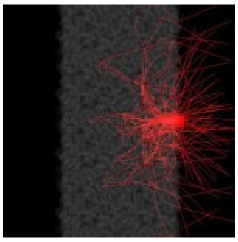
UE 8 Ceramics and Glasses

Objective : To provide a thorough knowledge of physical and chemical properties of various classes of materials belonging to ceramics or glasses and their industrial applications.



Chemical classification of materials, general properties of ceramics (in this large family of materials, the emphasis is on traditional ceramics, and how ceramics are present in the world around us: roof tiles and bricks, tiles, ceramics for electronics, cutting tools, refractory); traditional (silicate) ceramics; technical ceramics (used in thermomechanics/electrotechnics); refractory materials; production processes of ceramics (eg, from powders); adsorption isotherms, BET theory, specific surface area of ceramic powders. Glasses: definition of the glassy state, models and structural approaches; glass compositions, industrial glasses and special glasses; Glass transition, structural relaxation, lacunar model; devitrification; physical properties and optoelectronic applications.

UE 9: Electrochemistry



Objective : To provide the basic tools for diagnosis and prevention of corrosion.

Diagnosis and prevention of corrosion; mechanisms of corrosion: electrochemical theory and thermodynamics and kinetics of corrosion; passivation and methods of protection against corrosion; implementation of methods for corrosion studies.

UE 10 : Laboratory of Physics II

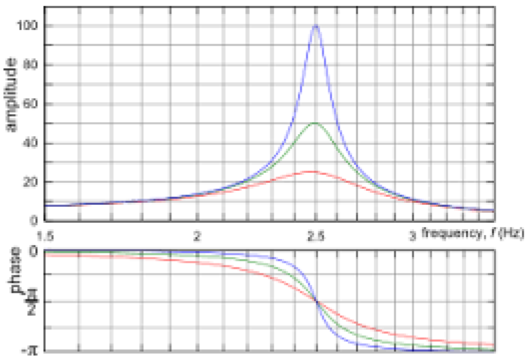
Objective: To develop the necessary practical skills for research activities and to complete the theoretical knowledge acquired in other UE by laboratory experiments This Laboratory corresponds to more advanced experiences than the equivalent laboratory of first semester (organized by the responsible according to the students' attitudes).

UE 11 : Spectroscopy

Objective : Spectroscopy is an essential tool in chemistry and physics. It plays a fundamental role in the characterization and comprehension of crystal and molecular structures. The goal of these lectures is to give students a large overview of the many techniques falling under the name 'spectroscopy'.

1. UV-visible spectroscopy. Theoretical introduction to UV-visible-NIR absorption:

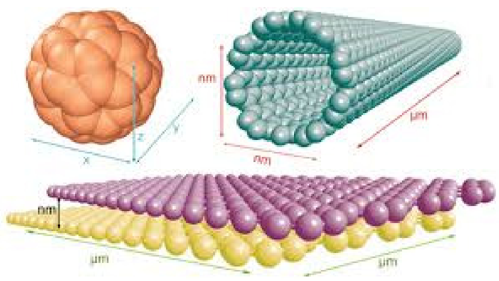
electronic transitions, selection rule, Franck-Condon principle, absorption spectra, experimental tools: spectrophotometers, recording spectra; Applications: spectrophotometry (Beer-Lambert Law), mixture analysis, determination of the equilibrium constant; dichroism. 2. IR and Raman spectroscopy. Introduction: principle of IR spectroscopy and selection rules; experimental tools: IR spectrometer (FTIR) and recording of spectra, characteristic absorption; Raman spectroscopy (principle, selection rules, interest and application). 3. Fluorescence spectroscopy: theoretical basis and characteristics (emission spectra and excitation lifetime, fluorescence quantum yield) Applications: Spectrofluorimetry; fluorescent markers and probes.



UE 12 : Diffusion, Diffraction, Resonances

Objective : The study of the phenomena of diffusion and diffraction, especially in correspondence of a resonance is an essential tool in physics, chemistry and materials science. It plays a crucial role in the understanding and characterization of molecular and crystalline structures. Lectures will be addressed by combining theoretical concepts and applied analysis. The goal is to give students the keys not only to understand the foundations of these phenomena, but also to have a tool of use in material science.

UE 13 : Introduction to Inorganic Nanomaterials



Objective : This teaching module is conceived to enable students to become familiar with the field of nanoscience, in particular nanomaterials. The concept of nanoscale is introduced and its influence on material properties is discussed: this represents a key points of the development and characterization of nanomaterials (nanoparticles, nanotubes, surfaces ...). Special attention is given to examples of nanomaterials and related applications (electronics, magnetism, optics, MEMS ...)

UE 14 : Internship

The internship should be obtained in an industrial laboratory, if possible abroad. Alternatively, a project in a University laboratory can also be presented.
It should last two months (three to four months is also possible), starting from May 2nd.
A written report is demanded

For more details ask to Prof. S. Di Matteo: Sergio.dimatteo@univ-rennes1.fr