MaMaSELF+

Master 2 Teaching Program at University of Rennes 1

Teaching and exams' organization

- Students attend first the two weeks summer-school dedicated to large scale facilities, holding in Montpellier and starting first week of September.
- Lectures at UR1 start on ~25 September and finish at the end of February. The teaching calendar as well as the exams' modalities are voted each year by the UR1 councils.
- There are two official lecture's interruption periods, one at Christmas time and one week at winter vacation time (mid to end of February).
- For each teaching module, students may have one or several written exams and/or oral exams. A final grade (out of 20) is given to each teaching module counting in the final cumulative GPA. Teaching modules grades and semester, respectively year, cumulative GPA are validated by an official jury composed meeting at the end of each semester.
- Lectures and exams schedules are available through students' intranet.
- All lectures are taken commonly with students from MaMaSELF 1st year students or with students from Physics master or Materials Science Engineering department from ESIR school
- The teaching program is organized in compulsory "Teaching blocks" to which the ECTS are associated. Each teaching block contains several teaching modules, mandatory and/or eligible (lectures, projects, seminars) with weighting coefficients related to their volume.

Teaching blocks and modules

UE01 Fundamental concepts of Materials Science 1 (6ECTS)

Materials science & statistical mechanics	Mandatory	16h	Coef. 0.333
• **Teacher**: P.Rabiller • **Synopsis**: This lecture covers fundamental concepts of statistical mechanics necessary to understand macroscopic properties of materials: entropy *vs.* information theory, density of states, Liouville space, partition function and thermodynamic potentials in the micro-canonical, canonical and grand-canonical cases, fluctuation/dissipation, and susceptibility. Mean field approach, Ising model, and introduction to phase transition or out of equilibrium properties may be explored upon lecture progress. • **Prerequisites**: Basic concepts in mechanics, thermodynamics, and quantum mechanics.			

Magnetism	Mandatory	20h	Coef. 0.333
• **Teacher**: S. Di Matteo, O. Cador • **Synopsis**: The first part of the lectures (8h) makes a survey of concepts in the domain of magnetism, both at the classical and at the quantum level. The formalism describing the origin of magnetism in materials is described and the Stoner-Wolffarth model to explain hysteresis cycles in ferromagnetic mono-domains is thoroughly discussed. The second part (12h) focuses on the quantum-mechanical applications at the atomic and nanometric scale, on the choice and characterization of materials, and on the routes used to conceive and design materials for industrial applications (magnets, magnetic probes, *etc.*). • **Prerequisites**: basics in electromagnetism, quantum mechanics, solid state and molecular chemistry			

Quantum chemistry	Eligible	22h	Coef. 0.333
• **Teacher**: X. Roquefelte • **Synopsis**: This teaching module intends to cover and consolidate basic concepts in Quantum Mechanics and their application to atoms and chemical bonds in extended solids, up to introduction of DFT methods • **Prerequisites**: Very basic concept in quantum mechanics.			

Scientific case study	Eligible		Coef. 0.333
• **Responsible**: P.Rabiller • **Synopsis**: In case an equivalent module to Quantum chemistry is already credited, the student can perform a scientific academic project on a particular case study concerning condensed matter and including significant part in fundamentals of solid state physics and/or chemistry. Regular meetings with a supervisor are organized to follow work in progress and advise the student.			

UE02 Fundamental concepts of Materials Science 2 (6ECTS)

Advanced seminars	Mandatory		
• **Responsible**: P.Rabiller • **Synopsis**: This module consists in series of seminar/tutorials given by invited lecturers mainly dealing with large scale facilities (neutron, synchrotron, x-ray free electron laser) and their application to material science.			

Magneto-electronics, Surfaces & interfaces	Mandatory	20h	Coef. 0.4
• **Teacher**: P.Turban • **Synopsis**: This lecture explores structure and properties of surfaces and multilayered materials where 2D effects are strongly prominent. A first part covers fundamentals and experimental characterization techniques for surface science. A second part focuses on multilayered structures with metal/semi-conductor and metal/oxide interfaces, with emphasis on magneto-electronic transport and giant or magnetic resistance (GMR, TMR) based devices, or spin valves, and magnetic sensors. • **Prerequisites**: basics in solid state physics, electromagnetics, crystallography.			

Crystallography 1	Eligible	20h	Coef. 0.3
• **Teacher**: P.Rabiller • **Synopsis**: This first part of crystallography lecture is devoted to extensive symmetry analysis of crystals: Curie & von Neuman principle, point symmetry, lattice translation, space groups. Geometric and algebraic description of symmetry operations are taught. At the end of the lecture a student is able to interpret space-groups tables and crystalline edifices. • **Prerequisites**: vectors and matrices algebra, basics in waves and Fourier transform			

Crystallography 2	Eligible	20h	Coef. 0.3

- **Teacher**: P.Rabiller
- **Synopsis**: This second part of crystallography lecture extensively describes the scattering of a wave (x-ray, neutrons or electrons) by a crystalline system. Starting form scattering by a single particle, the scattering by a perfect ideal 3D crystal is derived, introducing Bragg scattering and structure factor with all kinds of systematic extinctions. Diffuse scattering is introduced. The lecture mainly focuses on single crystal scattering, powder scattering being handled in chemistry labs. Data-collection and processing, structure determination (Patterson function, flip method), and structure refinement are introduced.
- **Prerequisites**: vectors and matrices algebra, basics in waves and Fourier transform

Spectroscopy	Eligible	16h	Coef. 0.3

- **Teacher**: S. di Matteo
- **Synopsis**: This lecture aims at teaching to the students the fundamentals of synchrotron-based spectroscopy, in order to understand x-ray absorption techniques such as X-ray Absorption Near-Edge Spectroscopy (XANES), Extended X-ray Fine-Structure Spectroscopy (EXAFS), Resonant X-ray Scattering, both Inelastic (RIXS) and Elastic (REXS)
- **Prerequisites**: basics in quantum mechanics

Project on Equilibrium properties of matter	Eligible		Coef. 0.3

- **Responsible**: P.Rabiller
- **Synopsis**: In case an equivalent module to crystallography or spectroscopy is already credited, the student can make a personal work and extend her/his knowledge on a chosen topic related to fundamentals of equilibrium properties of materials and including crystallographic, statistical physics, quantum, magnetic, electronic or electro-chemical aspects of condensed matter. The topic of interest must be validated by the supervisor and the work done under the guidance of the latter. A final report is produced.

UE03 Structure of Materials (6ECTS)

Structure and dynamics (NMR)	Mandatory	16h	Coef. 0.25

- **Teacher**: C.Odin
- **Synopsis**: This lecture aims at understanding principles and use of NMR technique as a probe to investigate structure and dynamics of materials. Typical pulse sequences are introduced, and it is shown how NMR spectra are related to interactions of nuclear spins with their local environment. The lecture is illustrated by various applications to condensed matter physics.
- **Prerequisites**: basics in quantum physics, electromagnetism, crystallography

X-ray physics and synchrotron sources	Mandatory	15h	Coef. 0.25

- **Teacher**: E.Collet
- **Synopsis**: This lecture covers main x-ray scattering and absorption techniques used at synchrotron and free electron laser sources for the investigation of the structure and dynamics of materials, with emphasis on phase transitions and ultrafast photo-switching materials.
- **Prerequisites**: basics in crystallography, electromagnetism

Monte Carlo simulations and modeling	Mandatory	16h	Coef. 0.25
• **Teacher**: A. Ghoufi • **Synopsis**: This lecture intends to introduce the Monte Carlo and Molecular Dynamics or related simulation methods which are widely used to model non analytical systems and investigate structure and dynamic properties of materials (averages and fluctuations). • **Prerequisites**: basics in statistical physics, algebra and numerical methods			

Project on structure and dynamics	Mandatory		Coef. 0.25
• **Responsible**: P.Rabiller • **Synopsis**: The student makes a personal work and extend her/his knowledge on a chosen topic related to an experimental technique used to investigate the structure and/or dynamics of materials. The scope of investigation covers the principle, the implementation, the limits, and typical application examples. The work is done under the guidance of a supervisor and may include short training on real experiments done in a research group at UR1.			

UE04 Materials Science & Engineering (9ECTS)

MaMaSELF summerschool on synchrotron and neutrons	Mandatory	60	0.6
The student attend the intensive summer-school dedicated to large scale facilities, namely neutron sources and synchrotron sources. Worldwide experts in the concerned field give lectures/tutorials on neutron physics, neutron elastic and inelastic or magnetic scattering, high resolution or in-situ x-ray Bragg and diffuse scattering (powder and single crystal), x-ray absorption spectroscopy (XANES, EXAFS, RIXS).			

Hybrid integrated photonics	Eligible	12h	Coef. 0.2
• **Teacher**: B.Bêche • **Synopsis**: Introduction to integrated photonics. Theory of advanced electromagnetic waveguides. Micro-photonics components and hybrid process for sensors and optical telecommunication applications. Nanophotonics, photonic structures, photonic crystals. • **Prerequisites**: basics in electromagnetics and solid state physics.			

Thin films	Eligible	16h	Coef. 0.2
• **Teacher**: V.Bouquet • **Synopsis**: This lecture covers main techniques to grow (CVD, sputtering, laser ablation) and characterize thin films structure and properties (diffraction, microscopy, magnetic and electric transport). • **Prerequisites**: basics in inorganic chemistry.			

Sensors	Eligible	12h	Coef. 0.2
• **Teacher**: O.Merdrignac • **Synopsis**: This lecture deals with the synthesis, characterization and application of inorganic materials used as sensors (for instance for gas or light detection and measurement, *etc.*). • **Prerequisites**: basics in inorganic chemistry			

Surface functionalization	Eligible	12h	Coef. 0.2
• **Teacher**: S.Guezo, F.Solal • **Synopsis**: This lecture focuses on the preparation, characterization and application of functionalized surfaces. • **Prerequisites**: basics in condensed matter			

UE05 Introduction to Professional World (3ECTS)

Master-thesis preparation	Mandatory		0.7
The student makes the necessary bibliographic search between mid-December and late February, and make preparatory work for their master-thesis, prior the placement in the research or R&D laboratory early March. This work is done under the guidance of the master-thesis supervisor and a supervisor at UR1. A synthetic report must be submitted before end of March for evaluation.			

Scientific communication	Mandatory	4	0.3
This module consists in tutorials given to present to the students basic concepts and techniques to make efficient scientific poster and oral presentations. The students make a direct application through an oral presentation made to 1st year students, and based on one of their personal project or case study.			

Preparing professional insertion	Eligible	6	
MaMaSELF students can attend, upon scheduling compatibility, the tutorials offered to all master students of the campus and dedicated to help the students to improve CV's, motivation letters, highlighting competences and personal skills, *etc*.			

UE06 Master-thesis (30ECTS)

Master-thesis	Mandatory		
• **Master-thesis work:** The 5 to 6 months long master-thesis work is done with a placement of at least 3 months in a research or R&D laboratory at one of the consortium or associated partner institutions, or at one partner large scale facilities or industrial partners. The master-thesis subject is chosen in a list of proposals approved by the consortium advisory board. This part of the work is evaluated by the master-thesis supervisor. • **Status meeting:** Students must attend the MaMaSELF Status Meeting holding in May, and make a presentation of their work in conditions similar to an international research conference. • **Manuscript & defense:** The student provides at the end of the master-thesis a manuscript and makes a defense in front of a jury.			