LMAPR2014 — Physics of Functional Materials

2014-2015

5.0 credits	37.5 h + 22.5 h	1q

Teacher(s) :	Piraux Luc ; Gonze Xavier ; Rignanese Gian-Marco ;
Language :	Anglais
Place of the course	Louvain-la-Neuve
Inline resources:	> http://icampus.uclouvain.be/claroline/course/index.php?cid=MAPR2014
Main themes :	The course covers in three themes. The first part gives an overview of functional materials, with a special emphasis for introducing ferroic materials. The second part deals with superconducting materials. The third part is dedicated to optical materials.
Aims :	Contribution of the course to the program objectives Axis Nº1 : 1.1 Axis Nº3 : 3.1 et 3.3 Axis Nº4 : 4.2, 4.3, et 4.4 Axis Nº5 : 5.3, 5.4, 5.5 et 5.6 Axis Nº6 : 6.1, 6.4 Specific learning outcomes of the course At the end of their classes, the students are expected to be able: To cite the different classes of materials illustrating these with examples of industrial applications and every-day life; To explain the symmetry and the microscopic origin of direct and coupling properties; To identify and grasp the various application domains of ferroic materials (ferromagnetism, ferroelectricity, ferroelasticity) ; To comprehend the theoretical foundations of superconductivity useful for engineers, to list the classes of materials used and their principal applications; To relate the optical properties of materials (in particular their frequency dependence) with their geometrical and electronic structure at the atomic level; To explain the physical mechanisms at the basis of industrial optical applications; To cite, classify, and describe relevant optical industrial materials. *The contribution of this Teaching Unit to the development and command of the skills and learning outcomes of the programme(s) can be accessed at the end of this sheet, in the section entitled “Programmes/courses offering this Teaching Unit”.*
Evaluation methods :	The students will be evaluated: -- by group on the basis of the written report of the work achieved and the oral presentation made to their colleagues ; -- individually through a written exam on the basis of precise objectives defined and announced in advance. The written exam will deall with the reports of the other groups. The questions are given in advance to the students. A mark will be given to each report and to each oral presentation. The global mark of the project will account for 75% of the final mark. This note is automatically transferred for the catch-up sessions of the academic year.
Teaching methods :	The class is organized on the basis of projects carried on by groups of 5-6 students. The different projects are presented during a plenary lecture at the beginning of the class. Each week, the groups discuss their progresses with one of the teachers. Their achievements are summarized in written report (in English) and presented orally to their colleagues. The reports will be read by their colleagues and will lead to a Q& mp;A session at the end of the oral presentation.
Content :	The first part presents the various types of materials and their classification with respect to their function. Particular attention is given to their use in the industry and in every-day life. The symmetry of the properties is discussed. A thermodynamic approach is introduced in order to distinguishing between direct and coupling properties. The microscopic origin of direct properties is discussed allowing to study the basics of magnetic (dia-, para-, ferro-, ferri-, et antiferro-magnetism) et dielectric (polar dielectrics, ferroelectricity) materials. The second part deals with superconducting materials. After a review of the historical background, the most important experimental facts and materials are presented. The theoretical framework is briefly sketched (London, BCS, Ginsburg-Landau) emphasizing the consequences. The use of superconductors is discussed for power transmission and high magnetic fields production. The notions of critical current and magnetic field and vortex lattices are introduced. The current/voltage characteristics of a superconducting junctions are described (Josephson effects), presenting practical applications such very sensitive detectors (SQUID) and high-frequency devices. The third part is devoted to optical materials with every-day-life applications. Absorption, emission, and propagation phenomena in condensed-matter are studied in detail. The theory is illustrated by analyzing various typical cases chosen among electroluminescent diodes (including their LASER irradiation), propagation and amplification in systems based on optical fibers, photovoltaic cells, LASER based on gemstones.

Bibliography :	On icampus, the students will find : the directives, the supporting slides or syllabi, the reports of previous years. Several books may also be found at the BST.
Other infos :	For this lecture, it is assumed that the students have already acquired the basic concepts of materials sciences, quantum physics, statistical physics, and materials physics taught in bac 2 and in bac 3 (for example, in the lectures LMAPR1805, LMAPR1491, and LMAPR1492).
Cycle and year of study :	> Master [120] in Physics > Master [120] in Biomedical Engineering > Master [120] in Physical Engineering > Master [120] in Chemical and Materials Engineering
Faculty or entity in charge:	FYKI