UCLouvain

lmapr2014

2026

Physics of Functional Materials

5.00 credits	37.5 h + 22.5 h	Q1

Teacher(s)	Gonze Xavier ;Hackens Benoît ;Rignanese Gian-Marco ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
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.
Learning outcomes	**At the end of this learning unit, the student is able to :** **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, 6.5 **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.
Evaluation methods	The skills of the students, both scientific and technical (Axis N°1) and relative to the other axes of the reference system (communication, project management ...) will be evaluated: 1. by group on the basis of the written report of the work achieved and the oral presentation made to their colleagues (typically between the weeks 9 and 13 of the teaching period); 2. individually with respect to their active participation to the weekly meetings with one of the teachers (continuous assessment); 3. individually through written quizzes following the oral presentations of the other groups (thus also before the examination period); 4. individually through a written exam on the basis of precise objectives defined and announced in advance (during the examination period). The written exam will concern the topics of the other groups. The repartition of points is as follows : "project" part (report/oral presentation/participation/quizz) for 2/3 of the total, and written examination for 1/3 of the total.
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 progress with one of the teachers (during these meetings, the teacher also provides some coaching about the skills related to axes 3-6 of the learning outcomes). Their achievements are summarized in a written report (in English) and presented orally (may be through a video, according to the year directives) to their colleagues. The reports will be read by their colleagues and will lead to a Q&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, solar concentrators and transparent conducting materials.
Inline resources	Moodle UCL
Bibliography	Des livres de support sont disponibles à la 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 for example in the lectures LMAPR1805, LMAPR1491, and LMAPR1492).
Faculty or entity in charge	FYKI

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [60] in Physics	PHYS2M1	5		
Master [120] in Chemical and Materials Engineering	KIMA2M	5		
Master [120] in Biomedical Engineering	GBIO2M	5		
Master [120] in Physical Engineering	FYAP2M	5		
Master [120] in Physics	PHYS2M	5		
Master [120] in Energy Engineering	NRGY2M	5		