UCL Université catholique de Louvain

LMAPR2014

2010-2011

Physics of Functional Materials

5.0 credits	37.5 h + 22.5 h	1q

Teacher(s) :	Rignanese Gian-Marco (coordinator) ; Gonze Xavier ; Piraux Luc ;
Language :	Anglais
Place of the course	Louvain-la-Neuve
Main themes :	The course is divided in three parts. The first part gives an overview of functional materials. The second part deals with superconducting materials. The third part is dedicated to optical materials. 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 proper-ties is discussed allowing to study the basics of magnetic (dia-, para-, ferro-, ferri-, et anti-ferro-magnetism) et dielectric (polar dielectrics, ferroelectricity) materials. The second part deals with superconducting materials. After a review of the historical back-ground, the most important experimental facts and materials are presented. The theoretical framework is briefly sketched (London, BCS, Ginsburg-Landau) emphasising the conse-quences. The use of superconductors is discussed for power transmission and high magnetic fields production. The notions of critical current and magnetic field, vortex lattices and dynam-ics are introduce, presenting practical applications. The current/voltage characteristics of a superconducting junction are described (Josephson effects, digital circuits). Finally, the use of superconductors is discussed for very sensitive detectors (SQUID) and high-frequency appli-cations. 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 analysing various typical cases such as electroluminescent diodes (including their LASER irradiation), propagation and amplification in systems based on optical fibres, photovoltaic cells, photosynthesis, coloration of minerals (especially gemstones).
Aims :	Introduction to physics of functional materials. At the end of their classes, students are expected to be able : 1. To cite the different classes of materials illustrating these with examples of industrial appli-cations and every-day life; 2. To explain the symmetry and the microscopic origin of direct and coupling properties; 3. To identify the elements of superconductivity useful for engineers and the classes of rele-vant materials; 4. To explain the theoretical foundations of superconductivity and to describe engineering applications; 5. To relate the optical properties of materials (in particular their frequency dependence) with their geometrical and electronic structure at the atomic level; 6. To explain the physical mechanisms at the basis of industrial optical applications; 7. 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".*
Content :	Part 1 : Functional materials 1.1 Materials classes and their practical use 1.2 Materials properties 1.2.1. Properties symmetry 1.2.2. Direct properties 1.2.3. Coupling properties Part 2 : Superconducting materials 1.1 Historical background, experimental effects and materials 1.2 Theoretical overview (London, BCS, Ginsburg-Landau) and consequences 1.3 Use of superconductors 1.4 Current / Voltage characteristics of superconducting junctions 1.5 Very sensitive detectors (SQUID) and high-frequency applications Part 3 : Optical materials. 3.1. Light / electromagnetism 3.2. Diffraction/absorption 3.3. Frequency response 3.4. Classical models 3.5. Quantum transition rates (including LASER effect) 3.6. Intra- and inter-band absorption 3.7. Absorption in insulators

	(including optical fibres and photo-voltaic cells) 3.8. Luminescence (electroluminescent diodes) 3.9. Organic materials and punctual defects (phosphorescence) Methods : Lectures, practical classes, exercises
Other infos :	MAPR 1805 Introduction to materials science (or a similar course) MAPR 1491 Supplements in physics (or a similar course) MAPR 1492 Materials physics (or a similar course)
Cycle and year of study :	> Master [120] in Chemical and Materials Engineering > Master [120] in Physical Engineering > Master [120] in Biomedical Engineering
Faculty or entity in charge:	FYKI