UCLouvain

lmapr2471 Transport phenomena in solids and nanostructures

2019

In view of the health context linked to the spread of the coronavirus, the methods of organisation and evaluation of the learning units could be adapted in different situations; these possible new methods have been - or will be - communicated by the teachers to the students.

5 credits	30.0 h + 30.0 h	Q2

Teacher(s)	Charlier Jean-Christophe ;Piraux Luc ;
Language :	English
Place of the course	Louvain-la-Neuve
Main themes	This lecture provides an overview of the main physical phenomena linked to electrical and thermal transport as well as thermoelectric effects in materials. It also gives an introduction to spintronics and introduces the key features of electrical transport in nanostructures and low-dimensional systems, including quantum phenomena. Finally, laboratories allow the students to become acquainted with the experimental setup used for the measurements of transport properties as a function of temperature and magnetic field.
Aims	**Contribution of the course to the program objectives** Axe Nº1 : 1.1 et 1.3 Axe Nº2 : 2.1 et 2.2 Axe Nº3 : 3.2 et 3.3 Axe Nº4 : 4.2 et 4.4 Axe Nº5 : 5.3 et 5.4 **Specific learning outcomes of the course** 1 1. To compare the different types of materials when considering their thermal and electrical properties; 2. To explain the physical mechanisms involved at the nanoscale for the electrical and thermal conductivity as well as the temperature and magnetic field dependences; 3. To identify the useful materials for thermoelectric conversion; 4. To describe the experimental set-up for electrical and thermal measurements; 5. To comprehend the theoretical foundations of spintronics and to indentify the useful materialsand their principal applications; 6. To identify the quantum phenomena responsible for the new transport properties observed innanostructures and low-dimensional systems; 7. To relate the transport properties of carbon nanostructures with their geometrical and electronic structure; 8. To become acquainted with the experimental setup used for the synthesis, characterisation and measurements of transport properties as well as the analysis of the results. - - - - *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	**Due to the COVID-19 crisis, the information in this section is particularly likely to change.** The students will be evaluated : • individually, through a written and/or an oral exam, on the basis of precise objectives defined and announced in advance; • by group, on the basis of the written report of the practical labs.
Teaching methods	**Due to the COVID-19 crisis, the information in this section is particularly likely to change.** Lectures (30 hours) alternate with practical labs totaling 30 hours on chosen subjects by the students. The practical labs enable to develop skills in various experimental methods (synthesis of nanostructures, use of characterization tools, design of an experimental set-up for electrical and thermal transport measurements, links between experimental results and theoretical knowledge). The class has about 8 weeks of practical labs for 2 hours each into groups of 3-4 students ; the remaining 6 weeks are mostly dedicated to tutoring sessions and guidance on the writing of the report.
Content	1 : Bulk materials • Electrical conductivity : Theoretical expressions - Comparison between metals, semiconductors and semi-metals ' Scattering mechanisms and temperature dependence ' Link with band structure

	• Thermal conductivity : Theoretical expressions for lattice and electronic thermal conductivity ' Scattering mechanisms and temperature dependence - Comparison between different types of materials • Introduction to thermoelectricity : Seebeck et Peltier effects ' Influence of material - Thermoelectric conversion • Experimental aspects: Set-up for electrical and thermal measurements • Influence of magnetic field : Effect of a magnetic field quantum states of the electron gas and on the electron transport 2 : Nanostructured materials andlow-dimensional systems • Magnetic nanostructures : Introduction to spintronics, giant magnetoresistance in magnetic multilayers, tunneling magnetoresistance in magnetic tunnel junctions, prospects and concrete applications in spintronics • 2D systems: Examples of two-dimensional electron gas, density of states, influence of a magnetic field, quantum Hall effect, weak/strong localisation • 1D systems: Examples of one-dimensional electron gas, density of states, diffusive and balistic transport, influence of a magnetic field, universal fluctuations of conductance, Coulomb blockade, quantization of conductance, Aharonov-Bohm effect • 0D systems: Examples of quantum dots, single-electron transistor, molecular transport
Inline resources	https://moodleucl.uclouvain.be/course/view.php?id=1 0023
Bibliography	Cours magistraux : les documents du cours (slides, articles de revue) sont disponibles sur Moodle. Quelques livres 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 in bac 2 and in bac 3 (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	Aims
Master [120] in Chemical and Materials Engineering	KIMA2M	5		
Master [120] in Physical Engineering	FYAP2M	5		