SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	Babeş-Bolyai University, Cluj-Napoca
1.2 Faculty	Physics
1.3 Department	Department of the Condensed Matter Phyiscs and Advanced Technologies
1.4 Field of study	Physics
1.5 Study cycle	Master
1.6 Study programme / Qualification	Solid State Physics/ Computational Physics/ Biomaterials/ Biophysics and Medical Physics/

2. Information regarding the discipline

2.1 Name of the discipline	Advanced Solid State Physics						
2.2 Course coordinator	Lect. Dr. Roxana Dudric						
2.3 Seminar coordinator	Lect. Dr. Roxana Dudric						
2.4. Year of study	1	2.5 Semester	1	2.6. Type of evaluation	E	2.7 Type of discipline	C

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	3	Of which: 3.2 course	2	3.3 seminar/laboratory	1
3.4 Total hours in the curriculum	42	Of which: 3.5 course	28	3.6 seminar/laboratory	14
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					40
Additional documentation (in libraries, on electronic platforms, field documentation)					24
Preparation for seminars/labs, homework, papers, portfolios and essays					42
Tutorship					3
Evaluations					3
Other activities:					-

3.7 Total individual study hours	112
3.8 Total hours per semester	154
3.9 Number of ECTS credits	5

4. Prerequisites (if necessary)

4.1. curriculum	• Solid State Physics, Semiconductors Physics
4.2. competencies	• Identification and use of the main laws and principles of physics in a given context

5. Conditions (if necessary)

5.1. for the course	• Lectures hall with video projector (beamer) and blackboard
5.2. for the seminar /lab activities	• Seminar hall with blackboard

6. Specific competencies acquired

Professional competencies	• The advanced using of the theoretical and experimental concept of the solid state physics. • At the end of this course, students should have the conceptual and mathematical tools to read current research papers in solid state physics and to understand the physical process underlying many solid state devices. • The development of some algorithms based on advanced models/theories. to solve problems.
Transversal competencies	• Identification of the advanced continuous formation opportunities and effective exploitation of learning techniques for the own development.. • Effective use of information sources and communication resources and training assistance, both in Romanian and in a foreign language

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	• The course extends the ideas developed in the introductory course Solid State Physics on the basis of the main models and new experimental data. It will develop the basic knowledge underlining the relationship between the crystal structure and the physical properties of solids.
7.2 Specific objective of the discipline	• Students will get a deeper insight on applications of classical and quantum descriptions to explain electronic properties of solids. • The Students will be introduced to the foundations of solid state physics and to the modern approaches that are in use for describing electronic correlations in solids and soft-matter. • The students will be able to characterize the solids from electrical, magnetic and thermal properties points of view.

8. Content

8.1 Course	Teaching methods	Remarks
1. The Crystal Structure of Solids: Lattice, Basis and Unit Cells, Classification of Bravais Lattices and Crystal Structures, Important Structures, Defects in Solids	Presentation, debate, lecture	2 hours
2. Crystallography: Symmetry Elements, Miller indices		2 hours
3. The Reciprocal Lattice and X-Ray and Neutron Crystallography		2 hours
4. Lattice Vibrations and Phonons: Brief review of		2 hours

the vibration modes in solid. Phonon dispersion. Phonon heat capacity. Einstein model. Debye model. Theory vs. experiment		
5. Electron levels in a periodic potential: Review of Free Electrons in Metals (Drude and Sommerfeld models), The ions periodic potential and Von Karman boundary conditions, the Bloch's theorem, Schrodinger equation in momentum space, Fermi energy and Fermi surface, Electrons in a weak periodic potential, Energy bands and their representation (extended, reduced, and repeated zone scheme)		4 hours
6. Methods for the calculation of electron levels in a solid: Nearly free electrons approximation, tight-binding (TB) method (application of the TB method to a band arising from s-levels), orthogonalized plane wave (OPW) method and pseudopotentials		2 hours
7. Computational Methods for Electronic structure calculation: *ab-initio* methods, Density-functional theory for electronic structure calculation		2 hours
8. Electronic structure, density of states and the physical properties of solids: Alkaline metals. Noble metals. Divalent and polyvalent metals. Doped and undoped semiconductors. Transition metals		2 hours
9. Thermal properties of solids: Phonon and Electron thermal conductivity (scattering mechanisms, heat capacity), Thermal conductivity in Isolators, Metals and Semiconductors		2 hours
10. Magnetic properties of matter: Quantum Theory of Diamagnetism and Paramagnetism, Paramagnetic Susceptibility of Conduction Electrons, Landau diamagnetism, Crystal Field Splitting, Magnetic exchanges including RKKY, SuperExchange, Double Exchange, Spin waves and Magnons, Mean field theory and Stoner magnetism		2 hours
11. Optical properties of solids: Review of Maxwell's equations in a nonmagnetic dielectric medium, Absorption and Reflection of light in solids, Kramers-Kronig relations, Polarization Mechanisms, Free carrier absorption of light in solids, Interband transitions in metals and semiconductors, Excitons		2 hours
12. Surfaces, Interfaces and Films: crystal structure (packing arrangements, close packed planes), Thermodynamics - change in free energy, phase diagrams. Kinetics - Fick's Laws, Diffusion coef, Arrhenius, Electronic Structure		4 hours
8.2 Seminar	Teaching methods	Remarks
1. Bravais Lattices and Crystal Structures		2 hours
2. Symmetry Elements, Miller indices		2 hours
3. The Reciprocal Lattice and X-Ray diffraction		2 hours

4. Drude and Sommerfeld models, Bloch electrons	Presentation, debate, experiment	1 hour
5. Nearly free electrons approximation, TB approximation		1 hour
6. Energy bands and energy band diagrams		2 hours
7. Magnon Contribution to specific heat		1 hour
8. Optical transitions		1 hour
9. Surfaces, Interfaces and Films		2 hours

Bibliography
[1] C. Kittel, Introduction to Solid State Physics, 7th ed., Wiley, 1996.
[2] Ashcroft N. W., Mermin N. D., Solid State Physics, Holt-Saunders International Editions Tokyo, 1981.
[3] U. Mizutani, Introduction to the Electron Theory of Metals, Cambridge University Press 2001.
[4] K. H. J. Buschow and F.R. de Boer, Physics of Magnetism and Magnetic Materials, Kluwer Academic Publishers, New York, Boston, Dordrecht, London, Moscow 2004
[5] M. Ohring, The Materials Science of thin films,1992 , Library of Condensed Matter physics Department
[6] Kasturi Chopra," Thin film phenomena" (Editura:McGraw-Hill Company)
[7] Handouts

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

- The content of the discipline is in accordance with the subjects who are studied in the same field in romanian and foreign universities and with the specific demands of research institutes, economy and labour market.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	- correctness of the knowledge - completeness of the knowledge	- Written evaluation	75
10.5 Seminar	-the ability to work with the gained knowledge. - the correctness and the originality of the homework	- Active presence in seminars - homeworks	25
10.6 Minimum performance standards			

- To be present at minimum 75% of seminars
- Basic knowledge of theory and ability to solve simple problems

Date 20.12.2018

Signature of course coordinator

Signature of seminar coordinator

Date of approval

Signature of the head of department

Prof. Dr. Romulus Tetean