SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	Babes-Bolyai University
1.2 Faculty	Physics
1.3 Department	Department of solid state physics and advanced technologies
1.4 Field of study	Physics
1.5 Study cycle	Master of Science
1.6 Study programme / Qualification	MSc./Solid State Physics/Biophysics and Medical Physics/Computational Physics

2. Information regarding the discipline

2.1 Name of the discipline			Advanced Solid State Physics				
2.2 Course coordinator			Vasile Crisan, Prof. Dr., Iosif G. Deac, Associate Prof. Dr.				
2.3 Seminar coordinator			Vasile Crisan, Prof. Dr., Iosif G. Deac, Associate Prof. Dr.				
2.4. Year of study	**1**	2.5 Semester	**I**	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	6

4. Prerequisites (if necessary)

4.1. curriculum	• Solid State and semiconductor Physics
4.2. competencies	• Identification and adecvated 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. • The development of some algorithms to solve problems . • Data processing and data acquisition by using the advanced computational systems. • Critical/constructive analysis of the results by using advanced models/theories.
Transversal competencies	• Identification of the advanced continuous formation opportunities and effective exploitation of learning techniques for the own development. • Identification of the roles and responsibilities in a team, and the application of effective work and relationship techniques in a team.

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	• the students will be they to be able to do some advanced and technological research in the field of solid state devices. • the students will be able to characterize the solids from electrical, magnetic and thermal properties points of view. • the students will also be able to find the correlations between the experimental data and the phenomenon under study.

8. Content

8.1 Course	Teaching methods	Remarks
Review of the basic solid state physics concepts. 1. **Introduction (Prof. V. Crisan)**		2 hours
Electrons in periodic potential. Born-von Karman conditions. Bloch Theorem. Fermi Surfaces. Nearly free electrons approximation. Pseudo-potential method. Tight binding approximation. LCAO method. Semiconductors. 2. **Electronic structure calculation. (Prof. V. Crisan)**		6 hours
3. **Density-functional theory for electronic structure calculation.** **(Prof. V. Crisan)**		6 hours

Generalities. Alkaline metals. Noble metals. Divalent and polyvalent metals. Doped and undoped semiconductors. Transition metals. Density of states and Pauli paramagnetism. Itinerant magnetism in solids. 4. **Electronic structure, density of states and the physical properties of solids.**		2 hours
de Haas–van Alphen effect. Photoemission spectroscopy. Angular-resolved photoemission spectroscopy (ARPES). Advantages and limitations. **5. Experimental techniques and principles of electronic structure-related phenomena.**		2 hours
Brief review of the vibration modes in solid. Phonon dispersion. Phonon heat capacity. Einstein model. Debye model. Theory vs. experiment. Phonons and thermal properties of solids. Phonon-phonon scattering. Normal and umklapp processes. Phonon thermal conductivity. **6. Phonons in solid**		2 hours
Electrical conductivity and the density of states. Electron-phonon scattering. The effect of impurities. Other scattering mechanisms. Temperature dependence of electrical resistivity. Electron heat capacity. Electron and thermal conductivity. **7. Electrical and thermal properties of metals**		2 hours
Polarization. Dielectric constant and polarizability. Clausius-Mossoti relation. Langevin function. Relaxation and dielectric losses. Ferroelectrics. Antiferroelectrics. Piezoelectricity. Ferroelectric domains. **8. Dielectric properties of solids**		2 hours
Point defects. Line defects. Dislocations. Surface defects. Bulk defects. Vacancies. Interstitial defects. Substitutional defects. Hume-Rothery rules. Dislocations. Grain boundaries. Non-stoichiometry. 9. **Defects in solids**		2 hours
Introduction to superconductors. Evidence of a phase transition. Meissner effect. Characteristic lengths in SC. Categories of SC-Type I and type II. Magnetic properties. Critical current density. Theoretical Concepts BCS. High temperature superconductors. Applications. 10. **Introduction to superconductivity**		2 hours

Bibliography

1. C. Kitel, Introduction to Solid State Physics (7ed., Wiley, 1996)
2. N. W. Ashcroft, N. D. Mermin, *Solid State Physics*, Saunders, 1976.

3. Ch. Enss, S. Hunklinger, Low-Temperature Physics, Springer-Verlag Berlin Heidelberg 2005.
4. U. Mizutani, Introduction to the Electron Theory of Metals, Cambridge University Press 2001.
5. I. G. Deac, Temperaturi ultrajoase în fizica experimentală a solidului, Ed. NapocaStar Cluj- Napoca, 2003.
6. V. Pop, I. Chicinaş, N. Jumate, Fizica materialelor. Metode experimentale, Ed. Presa Universitară Clujeană, Cluj-Napoca, 2001.
7. I. Pop, V.Crisan, Calculul benzilor de energie in corpul solid, Ed. Stiintifica, 1982
8. 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.

8.2 Seminar	Teaching methods	Remarks
1. Advanced electronic structure calculation (Prof. V. Crisan).		7 hours
2. Bravais lattices and X-ray diffraction	Exercise, demonstration, probelmatisation	2 hours
3. Good metals. Drude. Sommerfeld. Density of states 1D, 2 D, 3 D. Bad metal.		2 hours
4. Bloch electrons. Empty lattice model. NFE		1.5 hours
5. Tight binding approximation.		1.5 hours

Bibliography

1. C. Kitel, Introduction to Solid State Physics (7ed., Wiley, 1996)
2. N. W. Ashcroft, N. D. Mermin, *Solid State Physics*, Saunders, 1976.
3. U. Mizutani, Introduction to the Electron Theory of Metals, Cambridge University Press 2001.

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 course is congruent to the similar matter studied in representative European and national universities. In order to better adapt to the work market requirements, the content of the course was related with the main trends from this field in the regional scientific research, industry and business environment.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	-correctness and completeness of the knowledge. - logical coherence - the ability to use the scientific language	3 hours written exam	45%
	-criteria related to the dutifulness, the interest for individus study.	Active presence in courses	5%
10.5 Seminar/lab activities	the ability to work with the gained knowledge.	There will be two tests from problems	30%
	The corectness and the originality of the homework.	There will be two homeworks from problems	10%

	Involvment degree	Active presence in seminars	10% (the presence is compulsory, at least 80%
10.6 Minimum performance standards			
➢ basic elements of theory and to solve simple problems are requested. A candidate shall be declared to have passed the examination in a subject of study only if he/she secures not less than 50% of the total marks.			

Date	Signature of course coordinator	Signature of seminar coordinator
.....	.....	.....

Date of approval

.....

Signature of the head of department

.....….….....