SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	Babes-Bolyai University
1.2 Faculty	Physics
1.3 Department	Solid State Physics and Advanced Technologies
1.4 Field of study	Physics
1.5 Study cycle	Master
1.6 Study programme / Qualification	Solid State Physics

2. Information regarding the discipline

2.1 Name of the discipline	Solid State Electronics						
2.2 Course coordinator	Prof. Dr. Viorel Pop						
2.3 Seminar coordinator	Prof. Dr. Viorel Pop						
2.4. Year of study	**2**	2.5 Semester	**4**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**S**

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					77
Additional documentation (in libraries, on electronic platforms, field documentation)					20
Preparation for seminars/labs, homework, papers, portfolios and essays					17
Tutorship					3
Evaluations					3
Other activities:					–

3.7 Total individual study hours	120
3.8 Total hours per semester	162
3.9 Number of ECTS credits	5

4. Prerequisites (if necessary)

4.1. curriculum	Solid state Physics, Magnetism, Quantum Physics
4.2. competencies	Valorisation of physical fundamentals, of methods and tools of solid state physics and material science for specific applications. Use and development of research laboratory equipment and industrial laboratory for conducting research experiments.

5. Conditions (if necessary)

5.1. for the course	Classroom equipped with blackboard and projector

5.2. for the seminar /lab activities	Access to the research laboratory of Babes-Bolyai University

6. Specific competencies acquired

Professional competencies	**C1.** Using of advanced knowledge of physics, mathematics and chemistry of solids for study in Sold State Physics and Materials Science. Capacity for analysis and synthesis of physical data, the ability to model the physical processes that occur at contacts between different materials **C2.** Capitalization of physical fundamentals, of methods and tools of solid state physics and materials science for specific production activities, expertise and monitoring. Mindset multi-and interdisciplinary. **C3.** Planning and conducting experiments to assess the uncertainty and interpretation of the results. Use basic research laboratory equipment and industrial laboratory for conducting research experiments. **C4.** Communicating complex scientific ideas, conclusions or results of a scientific project experiments. Ability to obtain and argue scientific results, the ability to produce scientific papers and to relate to the editorial board of scientific journals of the field.
Transversal competencies	**CT1.** Fulfil the professional tasks effectively and responsibly with respect for law and ethics under qualified assistance. Responsible execution of professional duties in terms of autonomy and decision-making based on self-assessment. **CT2.** Effective work in multidisciplinary team on different hierarchical levels. Implementation of activities and fulfilling specific teamwork roles on different hierarchical levels, showing initiative and entrepreneurial leadership based on promoting dialogue, cooperation positive attitudes, mutual respect, diversity and multiculturalism and continuous improvement of their activities. **CT3.** Effective use of information sources and communication resources and training assistance, both in Romanian and in a foreign language. Objective self-evaluation of the need for continues training to labour market insertion and the adaptation to dynamic requirements of labour market.

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

7.1 General objective of the discipline	Thorough knowledge of the theoretical and practical aspects in solid state electronics and, within it, the proper use of specific language in communicating with different professional backgrounds.
7.2 Specific objective of the discipline	Valorisation of physical fundamentals, of theoretical and practical knowledge related to the study of the contact between electrical and magnetic materials with different contacts underlying solid state electronic devices, magnetic discs, magnetic sensors, magnetic memories, reading heads magnetic tapes and discs etc. Use and development of research and/or industrial equipments to perform research experiments.

8. Content

8.1 Course	Teaching methods	Remarks
1. Metal to metal contact. Energy diagram of steady state contact. Contact potential. Equilibrium condition at contact.	Lecture combined with debates. Will be used the video	2 h

2. Metal-semiconductor contact. Energy diagram of steady state contact. Volt-ampere characteristic. Barrier and anti barrier layer.	projector and the blackboard.	2 h
3.Degenerate and non degenerate semiconductor-semiconductor contact. Energy diagram of equilibrium contacts. Volt-ampere characteristic. Width of the barrier layer in p-n junction		2 h
4. Metal-oxide - semiconductor structure. Operating modes of the MOS structure. Inversion layer		2 h
5. Quantum Hall effect. Quantifying the Hall resistance		2 h
6. Magnetoresistance effects and their applications in spin electronics. Magnetic sensors		2 h
7. Anisotropic magnetoresistance (AMR) in ferromagnetic materials. Magnetoresistance dependence on the angle between current and magnetic field.		2 h
8. Magnetic multilayer metallic structures: magnetic-nonmagnetic-magnetic. Exchange coupling in magnetic multilayer structures.		2 h
9. Giant magnetoresistance (GMR) in magnetic multilayer structures. Spin valve. The spin-dependent electron scattering		2 h
10. Giant magnetoresistance (GMR) in granular heterogeneous systems. Magnetic clusters in non-magnetic matrices		2 h
11. Colossal magnetoresistance (CMR) in Mn oxides with perovskite-type structure. Double exchange mechanism		2 h
12. Tunnel magnetoresistance (TMR) in ferromagnet-insulator-ferromagnet structures. Tunneling probability depends on the spin orientation.		2 h
13. Extraordinary magnetoresistance (EMR) in magnetic semiconductors with metal impurities. Transition from low resistance state to high resistance state at a critical magnetic field.		2 h
14. Giant magneto-impedance (GMI) in soft magnetic wires and strips. Transverse permeability dependence vs. longitudinal applied magnetic field.		2 h

Bibliography

1. A. E. Berkowitz, J. R. Michell, M.J. Carey, A. P. Young, S. Zhang, F. E. Spada, F. T. Parker, A. Hutten, G. Thomas, Giant magnetoresistance in heterogeneous Cu-Co alloys, Phys. Rev. Lett. 68 (1992) 3745-3748
2. S. J. Blundell, Magnetism in condensed matter physics, Oxford University Press, Oxford, 2001
3. M. Coldea, Electronica solidului, Ed. Univ. Babeş-Bolyai, Cluj-Napoca, 2002
4. M. Coldea, Magnetorezistenta si aplicatiile ei, Presa Universitara Clujeana, 2009.
5. A. Fert, C. Vouille, Magnetoresistance Overview : AMR, GMR, TMR, CMR in 30. Ferienkurs des Instituts fur Festkorperforschung 1999, Magnetische Schichtsysteme, Forschungszentrum, Julich
6. R. F. Hummel, Electronic Properties of Materials, Springer-Verlag Berlin, 1993

7. M. Johnson, Spintronics, J. Phys. Chem. B, 109 (2005) 14278-14291
8. T. Thio, S. A. Solin, Extraordinary magnetoresistance in inhomogeneous narrow-gap semiconductors, Appl. Phys. Lett. 72 (1998) 4397- 4400
9. C. Tannous, J. Gieraltowski, Giant magneto-impedance and its applications, J. Mat. Science :Materials in electronics 15(2004)125-133

8.2 Seminar	Teaching methods	Remarks
1. Energy spectrum of electrons in solids: metals, insulators and semiconductors.	Critical presentation of given subjects. Will be used the video projector and the blackboard.	2 h
2. Calculation of thermoelectronic current emission to the surface of a metal and a semiconductor.		2 h
3. Super semiconductor networks. Energy spectrum and volt-ampere characteristic.		2 h
4. Materials used in spin electronics: ferromagnetic metals and alloys, antiferromagnetic materials, oxides, magnetic semiconductors, semimetals		2
5. Thin film magnetism: magnetic moment, anisotropy, domain structure.		2 h
6. Calculation of the tunnel current in metal-oxide-metal structures		1 h
7. Determining voltage and short circuit current of photovoltaic solar cells		2 h
8. Volt-ampere characteristic of metal-semiconductor contact		1 h

Bibliography

1. A. E. Berkowitz, J. R. Michell, M.J. Carey, A. P. Young, S. Zhang, F. E. Spada, F. T. Parker, A. Hutten, G. Thomas, Giant magnetoresistance in heterogeneous Cu-Co alloys, Phys. Rev. Lett. 68 (1992) 3745-3748
2. N. B. Brandt, S. M. Chudinov, Electronic structure of metals, Mir Publishers Moscow, 1975
3. M. Coldea, Electronica solidului, Ed. Univ. Babeş-Bolyai, Cluj-Napoca, 2002.
4. M. Coldea, Magnetorezistenta si aplicatiile ei, Presa Universitara Clujeana, 2009.
5. A. Fert, C. Vouille, Magnetoresistance Overview : AMR, GMR, TMR, CMR in 30. Ferienkurs des Instituts fur Festkorperforschung 1999, Magnetische Schichtsysteme, Forschungszentrum, Julich
6. R. Hermann, U. Preppernou, Elektronen im Kristall, Springer-Verlag, Wien, New york, 1979
7. R. F. Hummel, Electronic Properties of Materials, Springer-Verlag Berlin, 1993
8. M. Johnson, Spintronics, J. Phys. Chem. B, 109 (2005) 14278-14291
9. J. G. Simmon, Generalized formula for the electric tunnel effect between similar electrodes separated by a thin insulating film, J. Apll. Phys. 34(1963) 1793- 1803

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

Course content is consistent with what we study in other universities from Romania or abroad being adapted to the peculiarities of research activity at Babes-Bolyai University. To adapt to the requirements of the labour market, the content of these lectures was adjusted to the specific requirements of university education, research institutes and industry.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)

10.4 Course	Depth knowledge and understanding of concepts, basic theories and methods in Solid State Electronics. Using advance knowledge of material sciences for explanation and interpretation of new concepts, situations, processes, projects etc. associated to theoretical and practical knowledge of contacts between electrical and magnetic materials with different contacts underlying.	Solving and explaining complex problems in material science more precisely in physics of solid state electronics.	75
10.5 Seminar/lab activities	Integrated use of conceptual and methodological apparatus to solve theoretical and practical problems in solid state electronics. Nuanced and meaningful use criteria and assessment methods to make valuable judgments and promote constructive decisions.	Essay on an imposed theme, with public presentation. Lecture to strengthen experimental skills.	25
10.6 Minimum performance standards			

- Design of materials in accordance with quality management principles and elements considering environmental impact and health security.
- Use and development of research and/or industrial equipments to perform research experiments
- Planning and carrying out an experiment to validate a theoretical model in solid state electronics.

Date | Signature of course coordinator | Signature of seminar coordinator

20.12.2018 ....

Date of approval | Signature of the head of department

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