BACHELOR 'S PROGRAMME 3rd YEAR OF STUDY, 1st SEMESTER

COURSE TITLE	SOLID STATE AND SEMICONDUCTORS PHYSICS
COURSE CODE	
COURSE TYPE	full attendance
COURSE LEVEL	1st cycle (bachelor's degree)
YEAR OF STUDY, SEMESTER	3rd year of study, 1st semester
NUMBER OF ECTS CREDITS	6
NUMBER OF HOURS PER WEEK	7 (3 lecture hours + 4 seminar hours)
NAME OF LECTURE HOLDER	Conf. dr. George RUSU
NAME OF SEMINAR HOLDER	Conf. dr. George RUSU
PREREQUISITES	Advanced level of English

A GENERAL AND COURSE-SPECIFIC COMPETENCES

General competences:

- → Realization of a team activity and identification of specific professional roles

Course-specific competences:

- → Description of physical systems, using specific theories and tools (experimental and theoretical models, algorithms, schemes, etc.)
- → Proper use of numerical methods and mathematical statistics in the analysis and processing of specific physical data
- → Application of Physics knowledge both in given situations in related fields and in experiments, using standard laboratory equipment.
- → Explanation and interpretation of physical phenomena by formulating assumptions and operationalizing key concepts and proper use of laboratory equipment.

B LEARNING OUTCOMES

On successful completion of this course, the students will be able to:

- Explain the periodic atom distribution in the solid state and the consequences of this distribution;
- Explain the energy band structure, highlighting the differences between metals, semiconductors and insulators;
- Describe the charge carrier transport phenomena occurring in solid bodies;
- Describe the main investigation techniques of the solid state using the data for calculating characteristic parameters;
- Use laboratory equipment to characterize different solid state materials.

C LECTURE CONTENT

Main characteristics of the solid state. Crystalline lattice. Examples and properties. Bravais lattices. Planes and directions in real lattices, Miller indexes. Reciprocal lattice. Atomic coordinates, packing factor. Examples of crystalline structures (metallic, ionic and covalent crystals). Structural defects.
Crystalline bond. General properties. Van der Waals, hydrogen, metallic, ionic and covalent bonds.
Lattice vibrations. Cases of 1 and 2 atom base. Brillouin zones. Born-Karman conditions. Normal modes. Phonons.
Thermal properties of solids. Specific heat. Debye and Einstein models.
Energy bands in crystalline solids-phenomenological approach.
Electron energy spectra in the solid body. Schrödinger eq. for a crystal.
Different models for calculating energy spectra (Sommerfeld, adiabatic, Hartree-Fock, tight bonding electrons etc.). Bloch functions. k space. Fermi sphere and energy. Density of states. Kronig-Penney model.
Differences between metals and semiconductors (Mott-Gurney model).
Free charge carrier (CC) statistic in metals and semiconductors. Temperature dependence of CC concentration and Fermi level position in intrinsic and extrinsic semiconductors.
Transport phenomena in solids. Effective mass. Boltzmann eq. Scattering and relaxations mechanisms. Thermal conductivity. Diffusion. Electrical conductivity in metals and semiconductors.
Galvanomagnetic, thermoelectric and thermomagnetic effects.
Non equilibrium CC statistic. Drift and diffusion currents. Einstein relations.
Optical and photoelectrical phenomena in solids (absorption, photoconduction, Dember and photomagnetic effects, luminescence)
Magnetic properties of solids. Classification and models (dia-, para-, fero-, feri- etc.-magnetism). Dielectric properties of solids.
Basic methods for study of the solid body. X-ray diffraction (Bragg relation, Laue eqs., different techniques), tunneling microscopy, AFM techniques, etc.)

D RECOMMENDED READING FOR LECTURES

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E SEMINAR AND LABORATORY CONTENT

Laboratory content:
Presentation of rules for work safety and protection. Equipment and conduct of the activities.
Determination of the symmetry elements of the Bravais lattices.
Determination of crystalline grain size for different metallic, alloy and semiconducting materials.
Study of the crystal dislocations structure. Determination of dislocation density.
Temperature dependence of the electrical conductivity for metal and semiconductor materials. Determination of the semiconductor band-gap.
Study of the Hall effect. Applications.
Thermoelectrical (Seebeck) effect.
Study of the Peltier effect.
Photoconduction phenomena. Determination of optical band-gap from photoconduction spectra.
Optical absorption. Determination of the absorption spectra and optical activation energy.
Photovoltaic effect. Determination of solar cells efficiency.
Study of magnetization mechanism for ferro- and ferri-magnetic materials.
Study of dielectric properties of solids. Temperature dependence of permittivity.

Seminar content:
Symmetry elements of the crystalline lattices. Examples for 1 and 2 dimensional lattices.
Coordination number for some real crystalline structures. Determination of the primitive cells for complex lattices.
Atomic coordinates, atomic radius, package factor. Examples.
Determination of the Miller indexes for different planes and directions. Calculation of the interplanar spacing in different structures.
Presentation of the most important complex crystalline structures.
Determination of the total energy for van der Waals crystals and of the Madelung energy for ionic crystals.
Fermi level position in degenerate semiconductors. Degeneration criteria. Numeric examples.
Determination of some numeric values for typical parameters of semiconducting materials.
Determination of the dependence of Hall coefficient on temperature for n-type semiconductor.
Determination of some lattice parameters from X-Ray patterns.
Final conclusions

F RECOMMENDED READING FOR SEMINARS

1. P.W. ANDERSON, Basic Notions of Condensed Matter Physics, Benjamin, Menlo Park, 1984.
2. A. ANSELM, Introduction to Semiconductor Theory, Mir Publisher, Moscow, 1981.
3. N.W. ASHCROFT, N. D. MERMIN, Solid State Physics, Holt-Saunders International Editions, Tokyo, 1981.
4. B.E.P. BEESTON, R.W. HORNE, R. MORKHAM, Electron Diffraction and Optical Diffraction Tehniques in Practical Methods in Electron Microscopy, Ed. A M Glauert, North Holland, London, 1983.
5. J.S. BLAKEMORE, Semiconductor Statistics, Pergamon Press, London, 1962.
6. J.S. BLAKEMORE, Solid State Physics, W.B.Sauders Company, Phyladelphia – London – Toronto, 1970.
7. M. BORN, K. HUANG, Dynamical Theory of Crystals Lattices, Clarendon Press, Oxford, 1968.
8. F.C. BROWN, The Physics of Solid, Ionic Cristals Lattice Vibration and Imperfections, W.A. Benjamin, New York, 1967.
9. R.H. BUBE, Electronic Properties of Crystalline Solids, Academic Press, New York, 1974.
10. E. BURZO, Fizica fenomenelor magnetice, Editura Academiei Române, Bucureşti, vol. I(1979), vol. II(1981), vol III (1983).
11. J. CALLAWAY, Energy Band Theory, Academic Press, New York, 1964.
12. R.G. CHAMBERS, Electrons in Metals and Semiconductors, Chapman and Hall, London, 1990.
13. J.R. CHRISTMAN, Fundaments of Solid State Physics, J.Wiley, New York, 1988.
14. G. CIOBANU, C. CONSTANTINESCU, Fizica stării solide, vol. I, Editura Tehnică, Bucureşti, 1981.
15. CONSTANTINESCU, A. GLODEANU, Stări locale în semiconductori, Editura Acad. RSR, Bucureşti, 1967.
16. I. DIMA, I. LICEA, Fenomene fotoelectrice în semiconductori şi aplicaţii, Editura Academiei R.S.R., Bucureşti, 1980.
17. I. DIMA, I. MUNTEANU, Materiale şi dispozitive semiconductoare, Editura Didactică şi Pedagogică, Bucureşti, 1980.
18. V. DOLOCAN, Fizica electronică a stării solide, Bucureşti, 1984.
19. M. DRĂGĂNESCU, Electronica corpului solid, Editura Tehnică, Bucureşti, 1972.
20. G.I. EPIFANOV, Solid State Physics, Izd. Mir, Moscow, 1979.
21. G. FENG, G. JIN, Introduction to Condensed Matter Physics, Vol. I, World Scientific, Singapore, 2005.
22. W.A. HARRISON, Electronic Structure and Properties of Solids, vol I, Vol II, (Physics of the Chemical Bonds), W.H. Freman and Company, San Francisco 1980.
23. P.S. KIREEV, Fizica semiconductorilor, Editura Ştiinţifică şi Enciclopedică, Bucureşti, 1977.
24. KITTEL, Introducere în fizica corpului solid, Editura Tehnică, Bucureşti, 1973
25. C. KITTEL, Introduction to Solid State Physics, 7th edition, John Wiley, New York, 1995.
26. C. KITTEL, Quantum Theory of Solids, J. Wiley, New York-Lodon, 1963.
27. LONG, Energy Bands in Semiconductors, J. Wiley, New York, 1968.
28. L. MITOŞERIU, V. ŢURA, Fizica dielectricilor, Editura Universităţii "Al.I.Cuza" Iaşi, 1999.
29. T.S. MOSS, Optical Properties of Semiconductors, Butterworths Scientific Publications, London, 1959.

30. F.R.N. NABARRO, Theory of Crystal Dislocations, Clarendon Press, Oxford, 1967.
31. Al. NICULA, Fizica semiconductorilor şi aplicaţii, Editura Didactică şi Pedagocică, Bucureşti 1976.
32. Al. NICULA, I. FARKAS, Dielectrici şi feroelectrici, Editura Tehnică, Bucureşti, 1988.
33. J.I. PANKOVE, Optical Processes in Semiconductors, Dover, New York, 1971.
34. L. PAULING, The Nature of the Chemical Bond, Cornell University Press, New York, 1960.
35. I. POP, M. CRIŞAN, Fizica corpului solid şi a semiconductorilor, Ed. Ştiinţifică şi Pedagogică, Bucureşti, 1983.
36. I. POP, V. NICULESCU, Structura corpului solid (Metode fizice de studiu), Editura Academiei R.S.R., Bucureşti, 1974.
37. E.H. PUTLEY, The Hall Effect in Semiconductor Physics, Dover Publications, New York, 1960.
38. G.G. RUSU, C. BABAN, M. RUSU, Materiale şi dispozitive semiconductoare, Editura Universităţii „Al.I.Cuza" Iaşi, 2002.
39. G. RUSU, G. I. RUSU, Bazele fizicii semiconductorilor, Vol. I, Editura Universităţii „Alexandru Ioan Cuza", Iaşi, 2015.
40. G. RUSU, G. I. RUSU, Bazele fizicii semiconductorilor, Vol. II, Editura Universităţii „Alexandru Ioan Cuza", Iaşi, 2015.
41. G. RUSU, G. I. RUSU, Bazele fizicii semiconductorilor, Vol. III, Editura Universităţii „Alexandru Ioan Cuza", Iaşi, 2015.
42. G. G. RUSU, G. I. RUSU, Bazele fizicii semiconductorilor, Vol. IV, Editura Universităţii „Alexandru Ioan Cuza", Iaşi, 2016.
43. K. SEEGER, Semiconductor Physics, Springer-Verlag, Berlin-Heidelberg-New York, 1982, 1999.
44. W. SHOCKLEY, Electrons and Holes in Semiconductors, D.van Nostrand Company Inc., Princeton, New Jersey, Toronto, London, New York, 1950.
45. R.A. SMITH, Semiconductors, Cambridge University Press, 1980.
46. I. SPANULESCU, Celule solare, Editura Ştiinţifică şi Enciclopedică, Bucureşti, 1983.
47. TAUC, Photo- and Thermoelectric Effects in Semiconductors, Pergamon Press, New York, 1962.
48. H.F. WOLF, Semiconductors, Wiley-Interscience, New York, London, Sydney, Toronto, 1971.
49. G. ZET, D. URSU, Fizica stării solide, Editura Tehnică, Bucureşti, 1989.
50. A.C. SMITH, F.K. JANAK, R.B.ADLER, Electronic Conductions in Solids, McGraw Hill, New York, 1967.
51. I.I. NICOLAESCU et all, Fizica corpului solid-probleme rezolvate, Vol. I, II, Editura Europroduct, 2001.

G EDUCATION STYLE

LEARNING AND TEACHING METHODS	Problem solving, demonstration, collaboration Lecture, media presentation
ASSESSMENT METHODS	• Exam • Colloquium
LANGUAGE OF INSTRUCTION	English