

UNIVERSITY OF CHEMICAL TECHNOLOGY AND METALLURGY
FACULTY OF METALLURGY AND MATERIALS SCIENCE
COUNCIL OF MATERIALS SCIENCE

Approved by:

Dean Associate Prof. Dr. I. Gruev

EDUCATIONAL PROGRAM

Subject: Physics of Solids
Specialization: Materials Science
Educational Degree: Master
(with teaching in English)
Qualification: Engineer

Authors:

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/Associate Prof. Dr. S. Nedev/

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/Associate Prof. Dr. I. Yovchev/

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/Pr. Assist. Prof. Dr. R. Harizanova/

Head of the
Council of Materials Science:

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/Professor D. Sc. D. Angelova/

2006

I. Hours according to the educational plan

Type of occupation	Semester	Number of hours
1. Lectures	I	20
2. Seminars	I	10
3. Form of control	Examination	

II. Annotation

This course is intended for students, specializing in the field of materials science. It makes them acquainted with the basics of quantum mechanics, which are prerequisite for understanding of the most important notions and theoretical models used in solid state physics. Problems, related to lattice dynamics are considered – heat oscillations, heat capacities and heat conductivity. Special attention is paid to band theory and resonance methods for investigation of the solids structure. The course covers topics, concerning conductivity of metals and semiconductors, superconductivity and dielectric, magnetic and optical properties of solids.

Basic knowledge of calculus is needed for mastering of the course in solid state physics. Acquiring of the present course will assist the students to develop abilities for physical explanation of phenomena from various domains of materials science.

III. Lectures

I. Basics of quantum mechanics – 2 hours

1. Wave function. Application of the stationary Schrödinger's equation.

Physical interpretation of the wave function. Schrödinger's equation. Superposition principle. Uncertainty relations. Particle movement in one-dimensional and three-dimensional infinitely deep potential well. Tunneling of particle through potential barrier. Harmonic oscillator. – 2 hours

II. Foundations of solid state physics – 10 hours

2. Elements of physical statistics

Degenerate and non-degenerate micro-particle systems, fermions and bosons. Quantization of the phase space. Quantum statistics of Fermi-Dirac for the electron gas in metals. Quantum theory of free electrons. Density of states. – **2 hours**

3. Lattice dynamics

Heat oscillations of the lattice. Phonons and normal modes. Acoustic and optical oscillations. Heat capacities of solids – quantum theories of Einstein and Debye. Heat conductivity of solids. – **2 hours**

4. Band theory of solids

Origin of electron energetic bands in the lattice. Bloch function and Brillouin zones. Model of Kronig and Peni. Adiabatic and single electron approximation of Schrödinger's equation for solids. Pulse (k-space) space. Electron effective mass. – **3 hours**

5. Metals, insulators and semiconductors from the point of view of band theory

Filling of bands with electrons. Resonance methods for investigation of solids – nuclear magnetic resonance, electron paramagnetic resonance, Mössbauer effect. – **2 hours**

6. Contact phenomena

Contacts between metals, insulators and semiconductors. Rectifying effect. Tunneling phenomena. Surface phenomena – **1 hour**

III. Properties of solids – 8 hours

7. Electric properties of solids

Conductivity of metals. Metal alloys and semiconductors. Intrinsic conductivity and impurity conductivity in semiconductors. Generation and recombination of carriers. Photo-conductivity. Superconductivity. Josephson's effect. High temperature superconductivity. – **3 hours**

8. Magnetic properties of solids

Ferro- and antiferromagnetic properties. Magnetic hysteresis. Magnetic domains. Spin nature of ferromagnetism. Exchange interaction. Ferri-magnets. Ferrites. Characterization methods – **2 hours**

9. Dielectric properties of solids

Dielectric constants and polarizability. Dipole relaxation and dielectric losses. Ferroelectric properties of solids. – **1 hour**

10. Optical properties of solids

Direct and indirect transitions. Internal photo-effect. Excitons. Fluorescence. Experimental methods for determination of optical constants. Lasers. – **2 hours**

IV. Problem solving seminars in solid state physics

1. Schrödinger's equation. Particle in potential well. Tunneling of particle through potential barrier. Harmonic oscillator. – **1 hour**
2. Energy and heat properties of lattice. – **2 hours**
3. Band theory of solids. – **2 hours**
4. Properties of metals and alloys. Superconductivity. – **1 hour**
5. Properties of semiconductors. – **1 hour**
6. Ferro-, antiferro- and ferrimagnetic properties. – **1 hour**
7. Properties of dielectrics. – **1 hour**
8. Optical properties of solids. – **1 hour**

V. References

Basic:

1. N. Ashcroft and N. Mermin, "*Solid State Physics*", New York, Saunders, 1976.
2. C. Kittel, "*Introduction to Solid State Physics*", New York, John Wiley, 1996.
3. C. Kittel, "*Quantum Theory of Solids*", New York, John Wiley, 1987.

Additional:

4. J. Ziman, "*Principles of the Theory of Solids*", Cambridge, University Press, 1979.
5. M. Marder, "*Condensed Matter Physics*", New York, John Wiley, 2000.
6. P. de Gennes, "*Superconductivity of Metals and Alloys*", Addison-Wesley, 1966.