Basics of nanophysics

Lecturer: Kościelska Barbara (WFTiMS PG); 15 h

Course description:

The purpose of this lecture is to present the physical properties of nanostructures. It will start from the short introduction about chemical bonds, crystalline structure, band structure and density of states of three- dimensional materials. Also fundamentals of quantum mechanics will be introduced. During the course, electronic transport, thermal and magnetic properties of nanostructures will be discussed. Because of their special properties, photonic materials, carbon nanotubes and graphen will be discussed separately.

Course conspect:

1. Introduction.
    1.1. Bonding in elemental solids: covalent, metallic and van der Waals bonding.
    1.2. Bonding in multielement crystals: ionic, mixed ionic-covalent and hydrogen bonding.
    1.3. Crystalline structure of solids.
    1.4. Band structure of solids: free electron, nearly free electron and tight binding model.
    1.5. Density of states in 0D, 1D, 2D and 3D materials.

2. Quantum nature of nanoworld.
    2.1. Particle-wave nature of light and matter and the Heisenberg uncertainty principles.
    2.2. Schrödinger equation, quantum states and energies, tunneling effect, reflection and tunneling at a potential step, tunneling effect.
    2.3. The trapped particle in 1D, 2D and 3D.
    2.4. Quantum-well laser.

3. Electronic transport properties.
    3.1. Diffusive and ballistic electron flow.
    3.2. Landauer theory of quantum transport.
    3.3. Ballistic transport in nanorods and quantum point contact.
    3.4. Coulomb blocade and single electron transistor.
    3.5. Quantum Hall effect.

4. Thermal properties.
    4.1. Phonons and phonon density of states.
    4.2. Specific heat of solids: Einstein and Debye theory of specific heat.

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4.5. Thermal conductivity.

4.6. Thermoelectric figure of merit of superlattices and nanorods, superlattice micro-coolers.

5. Magnetic properties and spin transport.

5.1. Spin-orbit coupling.

5.2. Magnetism and magnetic behaviour in matrials: interaction between magnetic moments, dia-, para- and ferromagnetism.

5.3. Spin Hall effect.

5.4. Magnetic nanowires.

5.5. Giant magnetoresistance (GMR) and tunnel magnetoresistance (TMR).

5.6. Spin transistors.

6. Photonic materials.

6.1. Electromgnetism in mixed dielectric media.

6.2. 1D, 2D and 3D photonic crystals.

6.3. Photonic band gap.

7. Properties of carbon nanotubes and graphen.

Literature.

1. Joel I. Gersten et al. “The physcs and chemistry of materials“, Wiley.

2. Takaaki Tsurumi et al. “Nanoscale physics for materials science“, CRC Press.

3. Michael A. Stroscio “Phonons in nanostructures”, Cambridge University Press.

4. Thomas Heinzel “Mesoscopic electronic in solid state nanostructures”, Wiley.

5. John D. Joannopoulos et al. “Photonic crystals, molding the flow of light”, Princeton University Press.

TERMINY WYKŁADÓW			
Data	**Dzień tygodnia**	**Godzina**	**Sala**
15.04.2013	Poniedziałek	16-19	Budynek Nano 3/09
16.04.2013	Wtorek	16-19	Budynek Nano 3/14
17.04.2013	Środa	16-19	Budynek Nano 3/09
18.04.2013	Czwartek	16-19	Budynek Nano 3/09
19.04.2013	Piątek	16-19	Budynek Nano 3/09

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