

FYS-6216 Semiconductor Physics I

Credit units:	4 ECTS	
Lectures:	12 x 1–2 h Wed 14 – 16 SG312	Tapio Rantala, prof. SG219 FirstName.LastName@tut.fi http://www.tut.fi/~trantala/opetus
Exercises:	12 x 2 h Fri 12 – 14 SG312	Yousof Mardoukhi http://
Text book:	M. Balkanski and R.F. Wallis, Semiconductor Physics and Applications (OXFORD University Press), Chapters 1 – 9.	
Prerequisites:	Basic Semiconductor Technology, Solid State Physics	
Examination:	May 22, 2013	

SCHEDULE 2013

SemicPhys I, 2013

ii

	WEEK	Lecture	Exercise	Note!
January	2	Wed 1 – 2	Fri	
	3	Wed 3 – 4	Fri 1	
	4	Wed 5 – 6	Fri 2	
	5	Wed 7 – 8	Fri 3	
February	6	Wed 9 – 10	Fri 4	
	7	Wed 11 – 12	Fri 5	
	8	Wed 13 – 14	Fri 6	
	9	Wed 15 – 16	Fri 7	
	10			Exam week
March	11	Wed	Fri	
	12	Wed 17 – 18	Fri 8	
	13	Wed 19 – 20		Easter week
April	14		Fri 9	
	15	Wed 21 – 22	Fri 10	
	16	Wed 23 – 24	Fri 11	
	17	Wed	Fri 12	
	18	Wed	Fri	
May	19	Wed	Fri	
	20			Exam week
	21	Exam	Wed 22.5.2013	Exam week

1. Basic characteristics of semiconductors	1
1.1. Qualitative properties	2
1.2. Composition of semiconductors	3
1.3. Structure of solids	4
1.3.1. Crystalline and amorphous forms	4
1.3.2. Lattice and basis	5
1.3.3. Bravais lattices	6
1.3.4. Crystallographic terminology	7
1.3.5. Structures of Semiconductors	8
1.4. Chemical bonding in semiconductors	10
1.4.1. Diamond structure semiconductors	10
1.4.2. Zincblende structure semiconductors	12
1.4.3. Layered semiconductors	13
1.4.4. Wurtzite structure semiconductors	14
1.4.5. Other semiconductors	14
1.5. Growth of pure semiconductor crystals	15
2. Electronic energy bands: basic theory	19
2.1. Schrödinger equation	22
2.2. Electrons in a periodic potential	24
2.3. Schrödinger equation for a periodic potential	26
2.4. Expansion of the eigenfunction in plane waves	27
2.5. Bloch's theorem	28
2.6. Electrons in a weak periodic potential	29
2.7. Brillouin zones	30

2.8. Energy bands and energy band gaps	32
2.9. Tight binding method	35
2.9.1. Wannier functions	35
2.9.2. LCAO method	36
3. Electronic energy bands: semiconductors	41
3.1. Spin-orbit interaction	43
3.2. Electron-ion interaction and pseudopotentials	47
3.2.1. Orthogonalized plane wave method	47
3.2.2. Pseudopotential method	49
3.2.2.1. Empirical pseudopotential method	51
3.2.2.2. Nonlocal pseudopotential method	51
3.2.2.3. Ab initio pseudopotentials	54
3.3. Electron-electron interaction	55
3.3.1. Hartree method	55
3.3.2. Hartree-Fock method	56
3.3.3. Density functional theory (DFT)	59
3.3.4. Excited electronic states	62
3.4. The k -p method	63
3.4.1. Nondegenerate bands	63
3.4.2. Valence bands	69
3.4.3. Conduction bands	70
3.4.4. Zincblende structure semiconductors	71
3.5. Energy band structures for specific semiconductors	72
3.6. Modification of energy band gaps	72

4. Kinematics and dynamics of electrons and holes in energy bands	73
4.1. Group velocity	75
4.2. Inverse effective mass tensor	77
4.3. Force equation	78
4.4. Dynamics of electrons	79
4.5. Dynamics of holes	80
4.6. Experimental determination of effective masses: cyclotron resonance in semiconductors	81
4.6. Experimental determination of carrier charge and concentration: Hall effect	82
5. Electronic effects of impurities	83
5.1. Qualitative aspects of impurities	84
5.2. Effective mass theory	85
5.3. Donor impurities in Si and Ge	89
5.4. Donor impurities in III–V semiconductors	90
5.5. Acceptor impurities	90
5.6. Deep centers (syvät tilat)	91
5.7. Impurity bands	92
6. Semiconductor statistics	93
6.1. Intrinsic semiconductors	94
6.2. Extrinsic semiconductors	95

7. Lattice vibrations in semiconductors	97
7.1. Equations of motion	98
7.2. Monatomic linear chain	100
7.3. Diatomic linear chain	101
7.4. Three-dimensional crystals	102
7.5. Lattice dynamical models for semiconductors	103
7.6. Normal coordinate transformation	104
7.7. Vibrational specific heat	104
7.8. Anharmonic effects	104
8. Charge carrier scattering and transport properties	105
8.1. Simple phenomenological introduction to transport in semiconductors	106
8.1.1. Electric conduction current	106
8.1.2. Conductivity effective mass	107
8.1.3. Diffusion current	109
8.1.4. Displacement current	109
8.2. Boltzmann equation and its solution	110
9. Surface properties of semiconductors	113
9.1. Surface effects on electronic states	115

OPTO-1/2-JOHDEKURSSIT

SemicPhys I, 2007 vii

