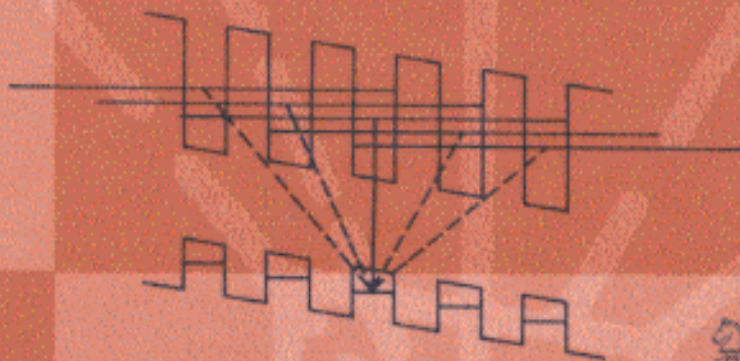


K. Seeger

Semiconductor Physics

An Introduction

8th Edition



Springer

Contents

1. Elementary Properties of Semiconductors	1
1.1 Insulator – Semiconductor – Semimetal – Metal	1
1.2 The Positive Hole	4
1.3 Conduction Processes, Compensation, Law of Mass Action	5
Problems	9
2. Energy Band Structure	10
2.1 Single and Periodically Repeated Potential Well	10
2.2 Energy Bands by Tight Binding of Electrons to Atoms	17
2.3 The Brillouin Zone	22
2.4 Constant Energy Surfaces	30
Problems	33
3. Semiconductor Statistics	35
3.1 Fermi Statistics	35
3.2 Occupation Probabilities of Impurity Levels	41
Problems	46
4. Charge and Energy Transport	
in a Nondegenerate Electron Gas	47
4.1 Electrical Conductivity and Its Temperature Dependence	47
4.2 Hall Effect in a Transverse Magnetic Field	52
4.3 Hall Techniques	63
4.4 Magnetoresistance	64
4.5 Corbino Resistance	68
4.6 Transport in Inhomogeneous Samples	72
4.7 Planar Hall Effect	74
4.8 Thermal Conductivity, Lorenz Number, Comparison with Metals	76
4.9 Thermoelectric (Seebeck) Effect	81
4.10 Thomson and Peltier Effects	87
4.11 Thermomagnetic Effects	92
4.12 Piezoresistance	99

4.13	Hot Electrons and Energy Relaxation Time	104
4.14	High-Frequency Conductivity	109
4.15	Noise	113
	Problems	115
5.	Carrier Diffusion Processes	118
5.1	Injection and Recombination	118
5.2	Diffusion and the Einstein Relation	120
5.3	The p-n Junction	126
5.4	Quasi-Fermi Levels	135
5.5	The Bipolar Transistor	137
5.6	The Metal - Semiconductor Contact	142
5.7	Various Types of Transistors Including MOSFET	144
5.8	Dember Effect and PEM Effect	151
5.9	Photovoltaic Effect	154
	Problems	157
6.	Scattering Processes in a Spherical One-Valley Model	159
6.1	Neutral Impurity Scattering	159
6.2	Elastic Scattering Processes	162
6.3	Ionized Impurity Scattering	166
6.4	Acoustic Deformation Potential Scattering of Thermal Carriers	171
6.5	Acoustic Deformation Potential Scattering of Hot Carriers	175
6.6	Combined Ionized Impurity and Acoustic Deformation Potential Scattering	180
6.7	Piezoelectric Scattering	184
6.8	The Phonon Spectrum of a Crystal	187
6.9	Inelastic Scattering Processes	192
6.10	Momentum Balance Equation and Shifted Maxwellian	196
6.11	Optical Deformation Potential Scattering	200
6.12	Polar Optical Scattering	205
6.13	Carrier - Carrier Scattering	214
6.14	Impurity Conduction and Hopping Processes	214
6.15	Dislocation Scattering	217
	Problems	221
7.	Charge Transport and Scattering Processes in the Many-Valley Model	222
7.1	The Deformation Potential Tensor	222
7.2	Electrical Conductivity	226
7.3	Hall Effect in a Weak Magnetic Field	230
7.4	The Weak-Field Magnetoresistance	232

7.5	Equivalent Intervalley Scattering and Valley Repopulation Effects	237
7.6	Nonequivalent Intervalley Scattering, Negative Differential Conductivity and Gunn Oscillations	242
7.7	The Acousto-Electric Effect	253
	Problems	262
8.	Carrier Transport in the Warped-Sphere Model	265
8.1	Energy Bands and Density of States	265
8.2	The Electrical Conductivity	270
8.3	Hall Effect and Magnetoresistance	271
8.4	Warm and Hot Holes	277
	Problems	278
9.	Quantum Effects in Transport Phenomena	280
9.1	Tunnel Diode, Resonant Quantum Wells, and Superlattices	280
9.2	Magnetic Quantum Effects	296
9.3	Magnetic Freeze-Out of Carriers	303
9.4	The Magnetophonon Effect	305
	Problems	311
10.	Impact Ionization and Avalanche Breakdown	312
10.1	Low-Temperature Impact Ionization in Homogeneous Semiconductors	312
10.2	Avalanche Breakdown in the p-n Junction	317
	Problems	323
11.	Optical Absorption and Reflection	324
11.1	Fundamental Absorption and Band Structure	324
11.2	Absorption Edge: Dependence on Temperature, Pressure, Alloy Composition, and Degeneracy	327
11.3	Exciton Absorption and Electron - Hole Droplets	335
11.4	Interband Transitions in a Magnetic Field	338
11.5	The Franz - Keldysh Effect (Electroabsorption and Electoreflectance)	340
11.6	Impurity Absorption	344
11.7	Lattice Reflection in Polar Semiconductors	350
11.8	Multiphonon Lattice Absorption	355
11.9	Quantum Mechanical Treatment of the Fundamental Optical Absorption Edge	356
11.10	Free-Carrier Absorption and Reflection	362

11.11	Cyclotron Resonance	374
11.12	Free-Carrier Magneto-Optical Effects	380
11.13	Interband Magneto-Optical Effects	390
11.14	Magnetoplasma Waves	392
11.15	Nonlinear Optics	394
	Problems	399
12.	Photoconductivity	402
12.1	Photoconduction Dynamics	402
12.2	Deep Levels in Germanium	407
12.3	Trapping Cross Section of an Acceptor	413
	Problems	416
13.	Light Generation by Semiconductors	417
13.1	The Luminescent Diode	418
13.2	The Semiconductor Laser	421
13.3	Optical Properties of Superlattices	432
	Problems	441
14.	Surface and Interface Properties and the Quantum Hall Effect	442
14.1	Surface States	442
14.2	Surface Transport and Photoemission	444
14.3	Surface Quantization	447
14.4	The Quantum Hall Effect	450
14.5	Quantum Wires, Dots, and Ballistic Transport	459
	Problems	470
15.	Miscellaneous Semiconductors	471
15.1	Amorphous Semiconductors	471
15.2	Effects of Deep-Level Impurities on Transport	475
15.3	Organic Semiconductors	478
15.4	Fullerenes	480
	Problems	481
Appendices		483
A.	Table A: Physical Constants	483
B.	Envelope wave function for Quantum Wells	484
C.	Table C: Semiconductor and Semimetal Data	486
References		487
Subject Index		518
About the Author		525