

Contents

1	Advances in Low-Dimensional Semiconductor Structures	1
	Hilmi Ünlü, Mohamed Rezaul Karim, H. Hakan Gürel, and Özden Akıncı	
1.1	Introduction	1
1.2	Superlattices and Quantum Wells	2
1.3	Strained Superlattices and Quantum Wells	6
1.4	Modulation-Doped Field Effect Transistors	8
1.5	Heterostructure Bipolar Transistors	9
1.6	Developments at Nanoscale	10
1.7	Conclusion	16
	References	17
2	Modeling of Low-Dimensional Semiconductors	19
	Hilmi Ünlü, H. Hakan Gürel, Özden Akıncı, and Mohamed Rezaul Karim	
2.1	Introduction	19
2.2	TB View of Semiconductor Structures	22
2.3	Semiempirical sp^3s^* TB Model	25
2.4	Band Structure of Ternary Semiconductors	28
2.5	Band Offsets in Ternary/Binary Structures	32
2.6	Semiempirical $sp^3d^5s^*$ TB Model	34
2.7	Conclusion	35
	References	37
3	Graphene: Properties and Theory	39
	Norman J. Morgenstern Horing	
3.1	Graphene	40
3.1.1	Device-Friendly Material Properties	40
3.1.2	Applications	40
3.1.3	Introduction: Sample Preparation Techniques: Original Experiments	40

3.1.4	Introduction: Structure	41
3.1.5	Introduction: Structure, Massless Dirac Spectrum	41
3.2	Graphene Hamiltonian I	41
3.3	Graphene Hamiltonian II	42
3.4	Graphene Hamiltonian III	42
3.4.1	Graphene: Green's Functions for Null Field and Finite Magnetic Field	43
3.4.2	Graphene Quantum Dot in Magnetic Field.....	45
3.4.3	More about Graphene Quantum Dots	47
3.5	Dielectric Screening Function, K, (on the 2D Graphene Sheet).....	47
3.5.1	Graphene Polarizability: Degenerate Limit ($T = 0^\circ\text{K}$, No Magnetic Field)	48
3.5.2	Graphene Plasmon	49
3.5.3	New Graphene Transverse Electric Mode in Terahertz Range	50
3.5.4	Coupling of Graphene and Surface Plasmons	50
3.6	Graphene Energy Loss Spectroscopy and van der Waals Interaction	51
3.6.1	Atom/Graphene van der Waals Interaction I	52
3.6.2	Atom/Graphene van der Waals Interaction II	52
3.6.3	Graphene Double Layer van der Waals Interaction	53
3.6.4	Graphene Quasiparticle Self-Energy, Σ	54
3.6.5	Electronic Superlattices in Corrugated Graphene	55
3.7	Graphene Transport: Experimental Background	55
3.8	Graphene Transport: Theoretical Background-A	56
3.9	Graphene Transport: Theoretical Background-B.....	56
3.10	Kinetic Equation for Graphene.....	57
3.10.1	Kinetic Equation Formulation for Current and Distribution Function	57
3.10.2	Kinetic Equation: Solution I	57
3.10.3	Kinetic Equation: Solution II	58
3.10.4	Kinetic Equation: Conductivity I	58
3.10.5	Static Screening Dielectric Function	59
3.10.6	Conductivity Results and Discussion I	59
3.10.7	Conductivity Results and Discussion II	59
3.10.8	Conductivity Results and Discussion III	60
3.10.9	Conductivity Results and Discussion IV	60
3.10.10	Conductivity Results and Discussion V	61
3.10.11	Conductivity Results and Discussion VI	61
3.11	Dynamic AC Conductivity	61
3.11.1	AC Kinetic Equation Formulation for Current and Distribution Function $\rightarrow \hat{\rho}$	62
3.11.2	Dynamic AC Conductivity	64
3.11.3	AC Conclusions.....	66
3.12	Device-Friendly Features of Graphene I.....	66
3.12.1	Device-Friendly Features of Graphene II.....	66

3.12.2	Device-Friendly Features of Graphene III	67
3.12.3	Device-Friendly Features of Graphene IV	67
3.12.4	Device-Friendly Features of Graphene V	68
3.12.5	Device-Friendly Features of Graphene VI	68
4	Functionalization of Graphene Nanoribbons	69
	Haldun Sevinçli, Mehmet Topsakal, and Salim Ciraci	
4.1	Introduction	69
4.2	Electronic and Magnetic Properties of 2D and 1D Graphene	71
4.2.1	Electrons in Honeycomb Lattice	71
4.2.2	Electronic and Magnetic Properties of GNRs	73
4.3	Functionalization Through Superlattice Formation	75
4.3.1	Superlattices of Armchair Graphene Nanoribbons.....	75
4.3.2	Superlattices of Zigzag Graphene Nanoribbons.....	82
4.4	Functionalization Through TM-Atom Doping	86
4.5	Conclusions	90
	References	91
5	Atom/Molecule van der Waals Interaction with Graphene	93
	Norman J. Morgenstern Horing, Vassilios Fessatidis, and Jay D. Mancini	
5.1	Introduction: Atom–Graphene van der Waals Interaction and the Plasma Image	93
5.2	Nonlocal Dipolar van der Waals Interaction of an Atom/Molecule and Graphene	97
	References	99
6	Optical Studies of Semiconductor Quantum Dots	101
	H. Yükselici, Ç. Allahverdi, A. Aşıkoğlu, H. Ünlü, A. Baysal, M. Çulha, R. İnce, A. İnce, M. Feeney, and H. Athalin	
6.1	Introduction	101
6.2	Solid-Phase Precipitation in Glass	102
6.3	Particle-in-a-Box Model to Determine the Average Nanocrystal Radius and Size Distribution	104
6.4	Raman and Photoluminescence Spectroscopies	108
6.5	Photoabsorption spectra	111
6.6	Quantum Dots in Solution Phase	113
6.7	Interferometric Analysis of QD Samples	114
	References	116
7	Friedel Sum Rule in One- and Quasi-One-Dimensional Wires	119
	Vassilios Vargiamidis, Vassilios Fessatidis, and Norman J. Morgenstern Horing	
7.1	Introduction	119
7.2	Local Density of States and Friedel Sum Rule for the One-Dimensional Wire	120
7.2.1	Local Density of States	122
7.2.2	Friedel Sum Rule	125

7.3	Friedel Sum Rule in a Quasi-One-Dimensional Wire.....	127
7.4	Summary	129
	References	130
8	Effects of Temperature on the Scattering Phases and Density of States in Quantum Wires	131
	Vassilios Vargiamidis, Vassilios Fessatidis, and Norman J. Morgenstern Horing	
8.1	Introduction	131
8.2	Formulation	133
	8.2.1 Local Density of States	133
	8.2.2 Scattering Phases	135
	8.2.3 Simple Model Scatterer	136
8.3	Finite Temperature Effects	138
8.4	Summary	141
	References	141
9	Fabrication of Low Dimensional Nanowire-Based Devices using Dielectrophoresis	143
	Ramazan Kizil	
9.1	Introduction	143
9.2	NanoGap Electrodes	145
9.3	Nanotechnology Applied to Bio/Molecular Detection and Nanogap Electrodes.....	146
9.4	Dielectrophoresis	147
9.5	Applications of DEP.....	148
9.6	Nanowire Synthesis and Characterization	148
9.7	Integration of Nanowires with a Microsystem	150
9.8	Microchip Design.....	150
9.9	Nanowire Alignment by DEP	151
	References	158
	Index	161

Low Dimensional Semiconductor Structures
Characterization, Modeling and Applications

Ünlü, H.; Horing, N.J.M. (Eds.)

2013, XIV, 162 p., Hardcover

ISBN: 978-3-642-28423-6