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半导体物理性能手册

第 1 卷

HANDBOOK ON PHYSICAL PROPERTIES OF SEMICONDUCTORS

Volume 1
Group IV Semiconductors



哈尔滨工业大学出版社
HARBIN INSTITUTE OF TECHNOLOGY PRESS



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Volume 1
Group IV Semiconductors

Edited by
Sadao Adachi



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by Sadao Adachi

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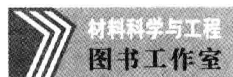
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PREFACE

The progress made in physics and technology of semiconductors depends mainly on three families of materials: the group-IV elemental, III–V, and II–VI compound semiconductors. The last five decades have seen an enormous investment in the research and application of semiconductors. Among the semiconductors most intensively studied have been silicon, germanium, and gallium arsenide. The wealth of information on such semiconductors is formidable. It is spread over a wide range of publications. Most of it exists in the form of individual research papers and reports. Some of it has been assembled into review articles, monographs, or parts of books.

The aim throughout has been to present in convenient form as large amount of accurate, reliable, and up-to-date information on the physical properties of the group-IV elemental semiconductors (diamond, Si, Ge, and α -Sn) and SiC polytypes for a variety of basic research and device applications. The data on the physical properties of each material are organized in the same way in order to facilitate searching for information. The physical properties considered in this book can be classified into 12 groups: (1) structural properties; (2) thermal properties; (3) elastic properties; (4) phonons and lattice vibronic properties; (5) collective effects and related properties; (6) energy-band structure: energy-band gaps; (7) energy-band structure: electron and hole effective mass; (8) electronic deformation potential; (9) electron affinity and Schottky barrier height; (10)

optical properties; (11) elastooptic, electrooptic, and nonlinear optical properties; and (12) carrier transport properties.

The extensive bibliography is included for those who wish to find additional information if required. I hope that the book will aid many who want to know various properties of those semiconductor materials in the course of their work. The reader will also find the series books “III–V Compound Semiconductors” and “II–VI Compound Semiconductors” useful in order to find the needed information quickly on these practically important semiconductors.

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The author wishes to thank the editors and authors of the following journals, symposium papers, and books for permission to reproduce previously published figures: *Academic Press* for Fig. 1.7.2; *Appl. Phys. Lett.* for Figs. 2.2.8, 2.9.8, 2.9.9, 2.10.7, 2.10.9, 2.12.8, 2.12.10, 2.12.24, 2.12.26, 2.12.30, 3.9.2, 3.12.15, 6.12.1, 6.12.6, 6.12.14, and 7.12.3; *Chem. Phys. Carbon* for Figs. 1.10.4 and 1.10.5; *Consultants Bureau* for Figs. 5.2.1 and 6.2.1; *High Temp.–High Press.* for Fig. 6.2.5; *IEEE J. Quantum Electron.* for Figs. 2.10.15 and 2.10.16; *IEEE Proc. Int. Electron Dev. Meeting* for Figs. 2.6.6 and 2.6.7; *IEEE Trans. Electron Dev.* for Figs. 6.12.10 and 6.12.11; *Inst. Phys. Conf. Ser.* for Figs. 6.9.4 and 6.12.13; *J. Appl. Phys.* for Figs. 2.7.1, 2.7.3, 2.10.6, 2.10.13, 2.12.12, 2.12.16, 2.12.17, 2.12.33, 3.12.10, 3.12.16, 5.6.2, 5.12.3, 6.6.2, 6.10.9, 6.12.3, and 7.12.1; *J. Chem. Phys.* for Fig. 1.2.1; *J. Cryst. Growth* for Fig. 4.12.4; *J. Opt. Soc. Am.* for Figs. 1.10.6, 2.10.5, 3.10.6, 6.10.7, 6.10.8, 7.10.3, and 7.10.4; *J. Phys. Chem. Solids* for Figs. 1.6.2, 3.10.13, 3.12.11, 3.12.14, 4.2.3, 4.6.4, 4.10.3, 4.12.1, and 4.12.3; *J. Phys.: Condens. Matter* for Fig. 2.9.6; *J. Phys. Soc. Jpn* for Figs. 3.7.1 and 5.6.3; *J. Vac. Sci. Technol.* for Fig. 2.9.4; *Jpn. J. Appl. Phys.* for Figs. 2.3.3, 2.12.25, 2.12.28, and 6.3.1; *Mat. Res. Soc. Symp. Proc.* for Fig. 6.9.2; *Mater. Sci. Eng.* for Fig. 2.6.4; *Mater. Sci. Semicond. Proc.* for Fig. 2.12.18; *Phys. Rev.* for Figs. 1.1.1, 1.2.8, 1.4.1–1.4.4, 1.6.1, 1.6.3, 1.7.1, 1.10.7, 1.11.1, 1.12.3, 1.12.5, 1.12.8, 1.12.9, 2.1.1, 2.2.1, 2.3.2, 2.4.1–2.4.3, 2.6.2, 2.6.3, 2.10.3, 2.10.8, 2.10.12, 2.10.14,

2.11.1–2.11.5, 2.12.2, 2.12.13, 2.12.14, 2.12.19, 2.12.20, 2.12.22, 3.2.1, 3.2.6, 3.4.1–3.4.4, 3.6.1–3.6.6, 3.7.2, 3.10.3, 3.10.4, 3.10.7, 3.10.8, 3.10.10, 3.10.12, 3.11.1–3.11.3, 3.12.3, 3.12.4, 3.12.6–3.12.9, 3.12.12, 4.2.1, 4.4.1–4.4.3, 4.6.1, 4.6.3, 4.6.5, 4.10.4–4.10.7, 5.4.1, 5.4.2, 5.10.4, 5.10.5, 5.11.1, 5.12.1, 6.4.1, 6.6.1, 6.10.6, 6.10.10, 6.11.1, 6.12.2, 7.4.1, 7.6.2, 7.10.5–7.10.7, and 7.11.1; *Phys. Rev. Lett.* for Figs. 1.2.7, 2.1.2, 2.4.4, 2.9.5, 3.1.1, and 5.1.1; *Phys. Status Solidi* for Figs. 2.12.5, 2.12.6, 5.10.6, 5.10.7, 6.6.3, 6.6.4, 6.10.11, 6.10.12, 7.6.1, 7.10.8, 7.10.9, and 7.12.2; *Proc. IEEE* for Figs. 1.12.10, 5.12.4, 5.12.5, and 6.12.12; *Proc. Roy. Soc.* for Figs. 1.10.8, 6.10.13, 7.10.2, and 7.10.10; *Solid State Commun.* for Figs. 1.12.1, 1.12.6, 1.12.7, 2.4.5, 2.10.10, 3.12.13, and 5.10.3; *Solid-State Electron.* for Figs. 2.7.2, 2.9.7, 2.12.1, 2.12.4, 2.12.7, 2.12.11, 5.12.6, and 6.12.15; *Sov. Phys.–Semicond.* for Fig. 3.10.9; *Springer-Verlag* for Figs. 2.12.15 and 2.12.21; *University of South Carolina Press* for Fig. 5.6.1; and *World Scientific* for Figs. 2.3.1, 2.12.27, and 2.12.31.

CONTENTS OF OTHER VOLUMES

HANDBOOK ON PHYSICAL PROPERTIES OF SEMICONDUCTORS II III–V Compound Semiconductors

Sadao Adachi, Author

- 1 Cubic Boron Nitride (*c*-BN)
- 2 Hexagonal Boron Nitride (*h*-BN)
- 3 Boron Phosphide (BP)
- 4 Boron Arsenide (BAs)
- 5 Wurtzite Aluminum Nitride (*w*-AlN)
- 6 Cubic Aluminum Nitride (*c*-AlN)
- 7 Aluminum Phosphide (AlP)
- 8 Aluminum Arsenide (AlAs)
- 9 Aluminum Antimonide (AlSb)
- 10 Wurtzite Gallium Nitride (α -GaN)
- 11 Cubic Gallium Nitride (β -GaN)
- 12 Gallium Phosphide (GaP)
- 13 Gallium Arsenide (GaAs)
- 14 Gallium Antimonide (GaSb)
- 15 Indium Nitride (InN)
- 16 Indium Phosphide (InP)
- 17 Indium Arsenide (InAs)
- 18 Indium Antimonide (InSb)

HANDBOOK ON PHYSICAL PROPERTIES OF SEMICONDUCTORS III II–VI Compound Semiconductors

Sadao Adachi, Author

- 1 Magnesium Oxide (MgO)
- 2 Zincblende Magnesium Sulphide (β -MgS)
- 3 Zincblende Magnesium Selenide (β -MgSe)
- 4 Zincblende Magnesium Telluride (β -MgTe)
- 5 Zinc Oxide (ZnO)
- 6 Wurtzite Zinc Sulphide (α -ZnS)
- 7 Cubic Zinc Sulphide (β -ZnS)
- 8 Zinc Selenide (ZnSe)
- 9 Zinc Telluride (ZnTe)
- 10 Cubic Cadmium Sulphide (*c*-CdS)
- 11 Wurtzite Cadmium Sulphide (*w*-CdS)
- 12 Cubic Cadmium Selenide (*c*-CdSe)
- 13 Wurtzite Cadmium Selenide (*w*-CdSe)
- 14 Cadmium Telluride (CdTe)
- 15 Cubic Mercury Sulphide (β -HgS)
- 16 Mercury Selenide (HgSe)
- 17 Mercury Telluride (HgTe)

CONTENTS

Preface

Acknowledgments

Contents of Other Volumes

1 Diamond (C)

1

- 1.1 Structural Properties / 1
 - 1.1.1 Ionicity / 1
 - 1.1.2 Elemental Isotopic Abundance and Molecular Weight / 1
 - 1.1.3 Crystal Structure and Space Group / 2
 - 1.1.4 Lattice Constant and Its Related Parameters / 2
 - 1.1.5 Structural Phase Transition / 2
 - 1.1.6 Cleavage Plane / 3
- 1.2 Thermal Properties / 4
 - 1.2.1 Melting Point and Its Related Parameters / 4
 - 1.2.2 Specific Heat / 4
 - 1.2.3 Debye Temperature / 6
 - 1.2.4 Thermal Expansion Coefficient / 7
 - 1.2.5 Thermal Conductivity and Diffusivity / 8
- 1.3 Elastic Properties / 10
 - 1.3.1 Elastic Constant / 10
 - 1.3.2 Third-Order Elastic Constant / 12

1.3.3 Young's Modulus, Poisson's Ratio, and Similar /	12
1.3.4 Microhardness /	13
1.3.5 Sound Velocity /	13
1.4 Phonons and Lattice Vibronic Properties /	14
1.4.1 Phonon Dispersion Relation /	14
1.4.2 Phonon Frequency /	14
1.4.3 Mode Grüneisen Parameter /	16
1.4.4 Phonon Deformation Potential /	16
1.5 Collective Effects and Related Properties /	17
1.5.1 Piezoelectric Constant /	17
1.5.2 Fröhlich Coupling Constant /	17
1.6 Energy-Band Structure: Energy-Band Gaps /	17
1.6.1 Basic Properties /	17
1.6.2 E_0 -Gap Region /	18
1.6.3 Higher-Lying Direct Gap /	19
1.6.4 Lowest Indirect Gap /	21
1.6.5 Conduction-Valley Energy Separation /	22
1.6.6 Direct-Indirect-Gap Transition Pressure /	22
1.7 Energy-Band Structure: Electron and Hole Effective Masses /	23
1.7.1 Electron Effective Mass: Γ Valley /	23
1.7.2 Electron Effective Mass: Satellite Valley /	23
1.7.3 Hole Effective Mass /	23
1.8 Electronic Deformation Potential /	26
1.8.1 Intravalley Deformation Potential: Γ Point /	26
1.8.2 Intravalley Deformation Potential: High-Symmetry Points /	27
1.8.3 Intervalley Deformation Potential /	27
1.9 Electron Affinity and Schottky Barrier Height /	28
1.9.1 Electron Affinity /	28
1.9.2 Schottky Barrier Height /	28
1.10 Optical Properties /	30
1.10.1 Summary of Optical Dispersion Relations /	30
1.10.2 The Reststrahlen Region /	31
1.10.3 At or Near the Fundamental Absorption Edge /	33
1.10.4 The Interband Transition Region /	35
1.10.5 Free-Carrier Absorption and Related Phenomena /	35
1.11 Elastooptic, Electrooptic, and Nonlinear Optical Properties /	36
1.11.1 Elastooptic Effect /	36
1.11.2 Linear Electrooptic Constant /	36
1.11.3 Quadratic Electrooptic Constant /	37
1.11.4 Franz-Keldysh Effect /	37
1.11.5 Nonlinear Optical Constant /	37
1.12 Carrier Transport Properties /	38
1.12.1 Low-Field Mobility: Electrons /	38
1.12.2 Low-Field Mobility: Holes /	39
1.12.3 High-Field Transport: Electrons /	41
1.12.4 High-Field Transport: Holes /	42
1.12.5 Minority-Carrier Transport: Electrons in p -Type Materials /	43
1.12.6 Minority-Carrier Transport: Holes in n -Type Materials /	43

1.12.7 Impact Ionization Coefficient / 44

2 Silicon (Si)**45**

- 2.1 Structural Properties / 45
 - 2.1.1 Ionicity / 45
 - 2.1.2 Elemental Isotopic Abundance and Molecular Weight / 45
 - 2.1.3 Crystal Structure and Space Group / 46
 - 2.1.4 Lattice Constant and Its Related Parameters / 46
 - 2.1.5 Structural Phase Transition / 46
 - 2.1.6 Cleavage Plane / 48
- 2.2 Thermal Properties / 49
 - 2.2.1 Melting Point and Its Related Parameters / 49
 - 2.2.2 Specific Heat / 49
 - 2.2.3 Debye Temperature / 50
 - 2.2.4 Thermal Expansion Coefficient / 51
 - 2.2.5 Thermal Conductivity and Diffusivity / 52
- 2.3 Elastic Properties / 55
 - 2.3.1 Elastic Constant / 55
 - 2.3.2 Third-Order Elastic Constant / 57
 - 2.3.3 Young's Modulus, Poisson's Ratio, and Similar / 58
 - 2.3.4 Microhardness / 59
 - 2.3.5 Sound Velocity / 60
- 2.4 Phonons and Lattice Vibronic Properties / 60
 - 2.4.1 Phonon Dispersion Relation / 60
 - 2.4.2 Phonon Frequency / 61
 - 2.4.3 Mode Grüneisen Parameter / 63
 - 2.4.4 Phonon Deformation Potential / 63
- 2.5 Collective Effects and Related Properties / 63
 - 2.5.1 Piezoelectric Constant / 63
 - 2.5.2 Fröhlich Coupling Constant / 63
- 2.6 Energy-Band Structure: Energy-Band Gaps / 64
 - 2.6.1 Basic Properties / 64
 - 2.6.2 E_0 -Gap Region / 65
 - 2.6.3 Higher-Lying Direct Gap / 67
 - 2.6.4 Lowest Indirect Gap / 70
 - 2.6.5 Conduction-Valley Energy Separation / 74
 - 2.6.6 Direct-Indirect-Gap Transition Pressure / 74
- 2.7 Energy-Band Structure: Electron and Hole Effective Masses / 75
 - 2.7.1 Electron Effective Mass: Γ Valley / 75
 - 2.7.2 Electron Effective Mass: Satellite Valley / 75
 - 2.7.3 Hole Effective Mass / 76
- 2.8 Electronic Deformation Potential / 78
 - 2.8.1 Intravalley Deformation Potential: Γ Point / 78
 - 2.8.2 Intravalley Deformation Potential: High-Symmetry Points / 80
 - 2.8.3 Intervalley Deformation Potential / 84
- 2.9 Electron Affinity and Schottky Barrier Height / 85
 - 2.9.1 Electron Affinity / 85
 - 2.9.2 Schottky Barrier Height / 85

- 2.10 Optical Properties / 93
 - 2.10.1 Summary of Optical Dispersion Relations / 93
 - 2.10.2 The Reststrahlen Region / 94
 - 2.10.3 At or Near the Fundamental Absorption Edge / 95
 - 2.10.4 The Interband Transition Region / 100
 - 2.10.5 Free-Carrier Absorption and Related Phenomena / 102
- 2.11 Elastooptic, Electrooptic, and Nonlinear Optical Properties / 103
 - 2.11.1 Elastooptic Effect / 103
 - 2.11.2 Linear Electrooptic Constant / 104
 - 2.11.3 Quadratic Electrooptic Constant / 104
 - 2.11.4 Franz–Keldysh Effect / 104
 - 2.11.5 Nonlinear Optical Constant / 104
- 2.12 Carrier Transport Properties / 106
 - 2.12.1 Low-Field Mobility: Electrons / 106
 - 2.12.2 Low-Field Mobility: Holes / 110
 - 2.12.3 High-Field Transport: Electrons / 115
 - 2.12.4 High-Field Transport: Holes / 119
 - 2.12.5 Minority-Carrier Transport: Electrons in *p*-Type Materials / 121
 - 2.12.6 Minority-Carrier Transport: Holes in *n*-Type Materials / 124
 - 2.12.7 Impact Ionization Coefficient / 126

3 Germanium (C)

131

- 3.1 Structural Properties / 131
 - 3.1.1 Ionicity / 131
 - 3.1.2 Elemental Isotopic Abundance and Molecular Weight / 131
 - 3.1.3 Crystal Structure and Space Group / 132
 - 3.1.4 Lattice Constant and Its Related Parameters / 132
 - 3.1.5 Structural Phase Transition / 132
 - 3.1.6 Cleavage Plane / 133
- 3.2 Thermal Properties / 134
 - 3.2.1 Melting Point and Its Related Parameters / 134
 - 3.2.2 Specific Heat / 134
 - 3.2.3 Debye Temperature / 135
 - 3.2.4 Thermal Expansion Coefficient / 136
 - 3.2.5 Thermal Conductivity and Diffusivity / 138
- 3.3 Elastic Properties / 140
 - 3.3.1 Elastic Constant / 140
 - 3.3.2 Third-Order Elastic Constant / 143
 - 3.3.3 Young's Modulus, Poisson's Ratio, and Similar / 143
 - 3.3.4 Microhardness / 144
 - 3.3.5 Sound Velocity / 144
- 3.4 Phonons and Lattice Vibronic Properties / 144
 - 3.4.1 Phonon Dispersion Relation / 144
 - 3.4.2 Phonon Frequency / 145
 - 3.4.3 Mode Grüneisen Parameter / 147
 - 3.4.4 Phonon Deformation Potential / 147
- 3.5 Collective Effects and Related Properties / 148
 - 3.5.1 Piezoelectric Constant / 148

3.5.2 Fröhlich Coupling Constant /	148
3.6 Energy-Band Structure: Energy-Band Gaps /	148
3.6.1 Basic Properties /	148
3.6.2 E_0 -Gap Region /	150
3.6.3 Higher-Lying Direct Gap /	153
3.6.4 Lowest Indirect Gap /	156
3.6.5 Conduction-Valley Energy Separation /	159
3.6.6 Direct-Indirect-Gap Transition Pressure /	159
3.7 Energy-Band Structure: Electron and Hole Effective Masses /	159
3.7.1 Electron Effective Mass: Γ Valley /	159
3.7.2 Electron Effective Mass: Satellite Valley /	160
3.7.3 Hole Effective Mass /	161
3.8 Electronic Deformation Potential /	162
3.8.1 Intravalley Deformation Potential: Γ Point /	162
3.8.2 Intravalley Deformation Potential: High-Symmetry Points /	165
3.8.3 Intervalley Deformation Potential /	169
3.9 Electron Affinity and Schottky Barrier Height /	170
3.9.1 Electron Affinity /	170
3.9.2 Schottky Barrier Height /	171
3.10 Optical Properties /	173
3.10.1 Summary of Optical Dispersion Relations /	173
3.10.2 The Reststrahlen Region /	174
3.10.3 At or Near the Fundamental Absorption Edge /	175
3.10.4 The Interband Transition Region /	179
3.10.5 Free-Carrier Absorption and Related Phenomena /	180
3.11 Elastooptic, Electrooptic, and Nonlinear Optical Properties /	180
3.11.1 Elastooptic Effect /	180
3.11.2 Linear Electrooptic Constant /	181
3.11.3 Quadratic Electrooptic Constant /	181
3.11.4 Franz-Keldysh Effect /	181
3.11.5 Nonlinear Optical Constant /	181
3.12 Carrier Transport Properties /	183
3.12.1 Low-Field Mobility: Electrons /	183
3.12.2 Low-Field Mobility: Holes /	185
3.12.3 High-Field Transport: Electrons /	188
3.12.4 High-Field Transport: Holes /	189
3.12.5 Minority-Carrier Transport: Electrons in p -Type Materials /	190
3.12.6 Minority-Carrier Transport: Holes in n -Type Materials /	192
3.12.7 Impact Ionization Coefficient /	193

4 Gray Tin (α -Sn)

195

4.1 Structural Properties /	195
4.1.1 Ionicity /	195
4.1.2 Elemental Isotopic Abundance and Molecular Weight /	195
4.1.3 Crystal Structure and Space Group /	196
4.1.4 Lattice Constant and Its Related Parameters /	196
4.1.5 Structural Phase Transition /	196
4.1.6 Cleavage Plane /	197

4.2 Thermal Properties /	197
4.2.1 Melting Point and Its Related Parameters /	197
4.2.2 Specific Heat /	197
4.2.3 Debye Temperature /	198
4.2.4 Thermal Expansion Coefficient /	199
4.2.5 Thermal Conductivity and Diffusivity /	200
4.3 Elastic Properties /	200
4.3.1 Elastic Constant /	200
4.3.2 Third-Order Elastic Constant /	200
4.3.3 Young's Modulus, Poisson's Ratio, and Similar /	200
4.3.4 Microhardness /	201
4.3.5 Sound Velocity /	201
4.4 Phonons and Lattice Vibronic Properties /	202
4.4.1 Phonon Dispersion Relation /	202
4.4.2 Phonon Frequency /	202
4.4.3 Mode Grüneisen Parameter /	204
4.4.4 Phonon Deformation Potential /	204
4.5 Collective Effects and Related Properties /	204
4.5.1 Piezoelectric Constant /	204
4.5.2 Fröhlich Coupling Constant /	204
4.6 Energy-Band Structure: Energy-Band Gaps /	204
4.6.1 Basic Properties /	204
4.6.2 E_0 -Gap Region /	206
4.6.3 Higher-Lying Direct Gap /	207
4.6.4 Lowest Indirect Gap /	209
4.6.5 Conduction-Valley Energy Separation /	210
4.6.6 Direct-Indirect-Gap Transition Pressure /	210
4.7 Energy-Band Structure: Electron and Hole Effective Masses /	210
4.7.1 Electron Effective Mass: Γ Valley /	210
4.7.2 Electron Effective Mass: Satellite Valley /	211
4.7.3 Hole Effective Mass /	211
4.8 Electronic Deformation Potential /	212
4.8.1 Intravalley Deformation Potential: Γ Point /	212
4.8.2 Intravalley Deformation Potential: High-Symmetry Points /	213
4.8.3 Intervalley Deformation Potential /	214
4.9 Electron Affinity and Schottky Barrier Height /	214
4.9.1 Electron Affinity /	214
4.9.2 Schottky Barrier Height /	214
4.10 Optical Properties /	214
4.10.1 Summary of Optical Dispersion Relations /	214
4.10.2 The Reststrahlen Region /	217
4.10.3 At or Near the Fundamental Absorption Edge /	217
4.10.4 The Interband Transition Region /	218
4.10.5 Free-Carrier Absorption and Related Phenomena /	219
4.11 Elastooptic, Electrooptic, and Nonlinear Optical Properties /	219
4.11.1 Elastooptic Effect /	219
4.11.2 Linear Electrooptic Constant /	219
4.11.3 Quadratic Electrooptic Constant /	219

- 4.11.4 Franz–Keldysh Effect / 219
- 4.11.5 Nonlinear Optical Constant / 219
- 4.12 Carrier Transport Properties / 220
 - 4.12.1 Low-Field Mobility: Electrons / 220
 - 4.12.2 Low-Field Mobility: Holes / 222
 - 4.12.3 High-Field Transport: Electrons / 223
 - 4.12.4 High-Field Transport: Holes / 223
 - 4.12.5 Minority-Carrier Transport: Electrons in *p*-Type Materials / 223
 - 4.12.6 Minority-Carrier Transport: Holes in *n*-Type Materials / 223
 - 4.12.7 Impact Ionization Coefficient / 223

5 Cubic Silicon Carbide (3C-SiC)

225

- 5.1 Structural Properties / 225
 - 5.1.1 Ionicity / 225
 - 5.1.2 Elemental Isotopic Abundance and Molecular Weight / 225
 - 5.1.3 Crystal Structure and Space Group / 226
 - 5.1.4 Lattice Constant and Its Related Parameters / 226
 - 5.1.5 Structural Phase Transition / 226
 - 5.1.6 Cleavage Plane / 227
- 5.2 Thermal Properties / 227
 - 5.2.1 Melting Point and Its Related Parameters / 227
 - 5.2.2 Specific Heat / 228
 - 5.2.3 Debye Temperature / 229
 - 5.2.4 Thermal Expansion Coefficient / 229
 - 5.2.5 Thermal Conductivity and Diffusivity / 230
- 5.3 Elastic Properties / 231
 - 5.3.1 Elastic Constant / 231
 - 5.3.2 Third-Order Elastic Constant / 231
 - 5.3.3 Young's Modulus, Poisson's Ratio, and Similar / 232
 - 5.3.4 Microhardness / 233
 - 5.3.5 Sound Velocity / 233
- 5.4 Phonons and Lattice Vibronic Properties / 233
 - 5.4.1 Phonon Dispersion Relation / 233
 - 5.4.2 Phonon Frequency / 234
 - 5.4.3 Mode Grüneisen Parameter / 235
 - 5.4.4 Phonon Deformation Potential / 236
- 5.5 Collective Effects and Related Properties / 237
 - 5.5.1 Piezoelectric Constant / 237
 - 5.5.2 Fröhlich Coupling Constant / 237
- 5.6 Energy-Band Structure: Energy-Band Gaps / 238
 - 5.6.1 Basic Properties / 238
 - 5.6.2 E_0 -Gap Region / 239
 - 5.6.3 Higher-Lying Direct Gap / 241
 - 5.6.4 Lowest Indirect Gap / 242
 - 5.6.5 Conduction-Valley Energy Separation / 244
 - 5.6.6 Direct–Indirect-Gap Transition Pressure / 244
- 5.7 Energy-Band Structure: Electron and Hole Effective Masses / 245
 - 5.7.1 Electron Effective Mass: Γ Valley / 245

- 5.7.2 Electron Effective Mass: Satellite Valley / 245
- 5.7.3 Hole Effective Mass / 246
- 5.8 Electronic Deformation Potential / 247
 - 5.8.1 Intravalley Deformation Potential: Γ Point / 247
 - 5.8.2 Intravalley Deformation Potential: High-Symmetry Points / 248
 - 5.8.3 Intervalley Deformation Potential / 249
- 5.9 Electron Affinity and Schottky Barrier Height / 249
 - 5.9.1 Electron Affinity / 249
 - 5.9.2 Schottky Barrier Height / 249
- 5.10 Optical Properties / 251
 - 5.10.1 Summary of Optical Dispersion Relations / 251
 - 5.10.2 The Reststrahlen Region / 255
 - 5.10.3 At or Near the Fundamental Absorption Edge / 256
 - 5.10.4 The Interband Transition Region / 258
 - 5.10.5 Free-Carrier Absorption and Related Phenomena / 258
- 5.11 Elastooptic, Electrooptic, and Nonlinear Optical Properties / 259
 - 5.11.1 Elastooptic Effect / 259
 - 5.11.2 Linear Electrooptic Constant / 259
 - 5.11.3 Quadratic Electrooptic Constant / 259
 - 5.11.4 Franz–Keldysh Effect / 259
 - 5.11.5 Nonlinear Optical Constant / 259
- 5.12 Carrier Transport Properties / 260
 - 5.12.1 Low-Field Mobility: Electrons / 260
 - 5.12.2 Low-Field Mobility: Holes / 261
 - 5.12.3 High-Field Transport: Electrons / 262
 - 5.12.4 High-Field Transport: Holes / 263
 - 5.12.5 Minority-Carrier Transport: Electrons in *p*-Type Materials / 263
 - 5.12.6 Minority-Carrier Transport: Holes in *n*-Type Materials / 263
 - 5.12.7 Impact Ionization Coefficient / 264

6 Hexagonal Silicon Carbide (2H-, 4H-, 6H-SiC, etc.)

265

- 6.1 Structural Properties / 265
 - 6.1.1 Ionicity / 265
 - 6.1.2 Elemental Isotopic Abundance and Molecular Weight / 265
 - 6.1.3 Crystal Structure and Space Group / 266
 - 6.1.4 Lattice Constant and Its Related Parameters / 266
 - 6.1.5 Structural Phase Transition / 267
 - 6.1.6 Cleavage Plane / 267
- 6.2 Thermal Properties / 267
 - 6.2.1 Melting Point and Its Related Parameters / 267
 - 6.2.2 Specific Heat / 268
 - 6.2.3 Debye Temperature / 269
 - 6.2.4 Thermal Expansion Coefficient / 269
 - 6.2.5 Thermal Conductivity and Diffusivity / 269
- 6.3 Elastic Properties / 272
 - 6.3.1 Elastic Constant / 272
 - 6.3.2 Third-Order Elastic Constant / 273
 - 6.3.3 Young's Modulus, Poisson's Ratio, and Similar / 273

6.3.4 Microhardness /	274
6.3.5 Sound Velocity /	275
6.4 Phonons and Lattice Vibronic Properties /	275
6.4.1 Phonon Dispersion Relation /	275
6.4.2 Phonon Frequency /	277
6.4.3 Mode Grüneisen Parameter /	279
6.4.4 Phonon Deformation Potential /	279
6.5 Collective Effects and Related Properties /	279
6.5.1 Piezoelectric Constant /	279
6.5.2 Fröhlich Coupling Constant /	279
6.6 Energy-Band Structure: Energy-Band Gaps /	280
6.6.1 Basic Properties /	280
6.6.2 E_0 -Gap Region /	281
6.6.3 Higher-Lying Direct Gap /	283
6.6.4 Lowest Indirect Gap /	283
6.6.5 Conduction-Valley Energy Separation /	286
6.6.6 Direct-Indirect-Gap Transition Pressure /	286
6.7 Energy-Band Structure: Electron and Hole Effective Masses /	286
6.7.1 Electron Effective Mass: Γ Valley /	286
6.7.2 Electron Effective Mass: Satellite Valley /	286
6.7.3 Hole Effective Mass /	288
6.8 Electronic Deformation Potential /	289
6.8.1 Intravalley Deformation Potential: Γ Point /	289
6.8.2 Intravalley Deformation Potential: High-Symmetry Points /	289
6.8.3 Intervalley Deformation Potential /	290
6.9 Electron Affinity and Schottky Barrier Height /	290
6.9.1 Electron Affinity /	290
6.9.2 Schottky Barrier Height /	291
6.10 Optical Properties /	294
6.10.1 Summary of Optical Dispersion Relations /	294
6.10.2 The Reststrahlen Region /	305
6.10.3 At or Near the Fundamental Absorption Edge /	307
6.10.4 The Interband Transition Region /	312
6.10.5 Free-Carrier Absorption and Related Phenomena /	313
6.11 Elastooptic, Electrooptic, and Nonlinear Optical Properties /	313
6.11.1 Elastooptic Effect /	313
6.11.2 Linear Electrooptic Constant /	313
6.11.3 Quadratic Electrooptic Constant /	313
6.11.4 Franz-Keldysh Effect /	313
6.11.5 Nonlinear Optical Constant /	314
6.12 Carrier Transport Properties /	315
6.12.1 Low-Field Mobility: Electrons /	315
6.12.2 Low-Field Mobility: Holes /	319
6.12.3 High-Field Transport: Electrons /	320
6.12.4 High-Field Transport: Holes /	322
6.12.5 Minority-Carrier Transport: Electrons in p -Type Materials /	322
6.12.6 Minority-Carrier Transport: Holes in n -Type Materials /	323
6.12.7 Impact Ionization Coefficient /	324