

Table of contents

Semiconductors

Subvolume A1 : Group IV elements, IV-IV and III-V compounds
Part β: Electronic, Transport, Optical and Other Properties
(edited by U. Rössler)

List of frequently used symbols and abbreviations; conversion tables XIV

1. Symbols XIV

2. Abbreviations XVIII

3. Conversion tables XX

1 Elements of the IVth group and IV-IV compounds 1

1.0 Structure, chemical bond (R. BLACHNIK) 1

1.0.1 Normal pressure and high pressure phases of group IV elements and IV-IV compounds 1

Figures for 1.0 4

References for 1.0 6

1.1 Diamond (C) (Sects. 1.1.1,4: R. SAUER; sect. 1.1.6: R. BLACHNIK) 7

1.1.1 Electronic properties 7

1.1.4 Transport properties 8

1.1.6 Further properties 8

Figures for 1.1 9

References for 1.1 10

1.2 Silicon (Si) 11

1.2.6 Further properties (R. BLACHNIK) 11

Figures for 1.2. 13

References for 1.2 17

1.3 Germanium (Ge). 18

1.3.6 Further properties (R. BLACHNIK). 18

Figures for 1.3. 18

References for 1.3 19

1.4 Grey tin (α -Sn) no update

1.5	Silicon carbide (SiC) (Sects. 1.5.1,4,5: R.P. DEVATY; sect. 1.5.6: R. BLACHNIK)	20
1.5.1	Electronic properties	20
1.5.4	Transport properties	24
1.5.5	Optical properties	26
1.5.6	Further properties	27
	Figures for 1.5	30
	References for 1.5	45
1.6	$\text{Si}_x\text{Ge}_{1-x}$ (R. BLACHNIK)	48
	Figures for 1.6	49
	References for 1.6	49
2	III-V compounds	50
2.0	Structure, chemical bond (R. BLACHNIK, with additions of W. KULISCH)	50
2.0.1	Properties of high pressure phases of III–V compounds	50
	Figures for 2.0.	63
	References for 2.0.	71
2.1	Boron nitride (BN) (Sects. 2.1.A.1,3,4,5, 2.1.B.1,3,4,5, 2.1.C.1,3,5, 2.1.D.1,3: W. KULISCH, with additions of R. BLACHNIK; sects. 2.1.A.6, 2.1.B.6, 2.1.C.6, 2.1.D.6: R. BLACHNIK, W. KULISCH)	73
2.1.A	Cubic boron nitride	73
2.1.A.1	Electronic properties	73
2.1.A.3	Lattice properties	75
2.1.A.4	Transport properties	76
2.1.A.5	Optical properties	77
2.1.A.6	Further properties	77
2.1.B	Hexagonal boron nitride	82
2.1.B.1	Electronic properties	82
2.1.B.3	Lattice properties	83
2.1.B.4	Transport properties	85
2.1.B.5	Optical properties	85
2.1.B.6	Further properties	86
2.1.C	Wurtzite boron nitride	90
2.1.C.1	Electronic properties	90
2.1.C.3	Lattice properties	91
2.1.C.5	Optical properties	91
2.1.C.6	Further properties	92
2.1.D	Rhombohedral boron nitride	94
2.1.D.1	Electronic properties	94
2.1.D.3	Lattice properties	94
2.1.D.6	Further properties	95
	Figures for 2.1	98
	References for 2.1	119
2.2	Boron phosphide (BP) (Sects. 2.2.1,3,4,5: Y. KUMASHIRO; sect. 2.2.6: R. BLACHNIK, with additions of Y. KUMASHIRO)	122
2.2.1	Electronic properties	122
2.2.3	Lattice properties	122
2.2.4, 5	Transport and optical properties	123

X	Table of contents	
2.2.6	Further properties	123
	Figures for 2.2	124
	References for 2.2	128
2.3	Boron arsenide (BAs) (Y. KUMASHIRO)	129
2.3.1	Electronic properties	129
2.3.3	Lattice properties	129
	Figures for 2.3	129
	References for 2.3	130
2.3a	Boron antimonide (BSb) (Y. KUMASHIRO)	130
2.3a.1	Electronic properties	130
2.3a.3	Lattice properties	131
	Figure for 2.3a	131
	References for 2.3a	131
2.4	Aluminum nitride (AlN) (Sects. 2.4.1,3,5: B.K. MEYER; sect. 2.4.6: R. BLACHNIK, with additions of B.K. MEYER)	132
2.4.1	Electronic properties	132
2.4.3	Lattice properties	134
2.4.5	Optical properties	135
2.4.6	Further properties	136
	Figures for 2.4	138
	References for 2.4	139
2.5	Aluminum phosphide (AlP)	141
2.5.6	Further properties (R. BLACHNIK)	141
	Figure for 2.5	142
	References for 2.5	142
2.6	Aluminum arsenide (AlAs) (Sects. 2.6.1,4,5: S. ADACHI; sect. 2.6.6: R. BLACHNIK)	143
2.6.1	Electronic properties	143
2.6.4	Transport properties	147
2.6.5	Optical properties	148
2.6.6	Further properties	149
	Figures for 2.6	149
	References for 2.6	154
2.7	Aluminum antimonide (AlSb) (Sect. 2.7.1,5: F. FUCHS; sect. 2.7.6: R. BLACHNIK)	156
2.7.1	Electronic properties	156
2.7.5	Optical properties	157
2.7.6	Further properties	159
	Figures for 2.7	160
	References for 2.7	161
2.8	Gallium nitride (GaN) (Sects. 2.8.A.1,3,4,5, 2.8.B.1,3,4,5: B.K. MEYER, with additions of R. BLACHNIK; sect. 2.8.A.6, 2.8.B.6: R. BLACHNIK, B.K. MEYER)	162
2.8.A	Cubic gallium nitride (β -GaN)	162
2.8.A.1	Electronic properties	162
2.8.A.3	Lattice properties	164

2.8.A.4	Transport properties	165
2.8.A.5	Optical properties	166
2.8.A.6	Further properties	166
	Figures for 2.8.A	166
	References for 2.8.A	168
2.8.B	Hexagonal gallium nitride (α -GaN)	170
2.8.B.1	Electronic properties	170
2.8.B.3	Lattice properties	179
2.8.B.4	Transport properties	181
2.8.B.5	Optical properties	183
2.8.B.6	Further properties	183
	Figures for 2.8.B	184
	References for 2.8.B	195
2.9	Gallium phosphide (GaP)	199
2.9.6	Further properties (including some lattice properties) (R. BLACHNIK)	199
	References for 2.9	200
	Figures for 2.9	201
2.10	Gallium arsenide (GaAs) (Sects. 2.10.1,4,5: S. ADACHI; sect. 2.10.6: R. BLACHNIK)	202
2.10.1	Electronic properties	202
2.10.4	Transport properties	211
2.10.5	Optical properties	215
2.10.6	Further properties (including some lattice properties)	217
	Figures for 2.10	219
	References for 2.10	238
2.11	Gallium antimonide (GaSb) (Sects. 2.11.1,4,5: F. FUCHS; sect. 2.11.6: R. BLACHNIK)	244
2.11.1	Electronic properties	244
2.11.4	Transport properties	246
2.11.5	Optical properties	247
2.11.6	Further properties (including some lattice properties)	247
	Figures for 2.11	248
	References for 2.11	254
2.12	Indium nitride (InN) (Sects. 2.12.1,4: B.K. MEYER; sects. 2.12.3,6: R. BLACHNIK)	255
2.12.1	Electronic properties	255
2.12.3	Lattice properties	256
2.12.4	Transport properties	257
2.12.6	Further properties	257
	Figures for 2.12	258
	References for 2.12	260
2.13	Indium phosphide (InP) (Sects. 2.13.1,4,5: A. HANGLEITER; sect. 2.13.6: R. BLACHNIK)	261
2.13.1	Electronic properties	261
2.13.4	Transport properties	262
2.13.5	Optical properties	262
2.13.6	Further properties (including some lattice properties)	262
	Figures for 2.13	264
	References for 2.13	269

2.14	Indium arsenide (InAs) (Sects. 2.14.1,4: A. HANGLEITER; sect. 2.14.6: R. BLACHNIK)	271
2.14.1	Electronic properties	271
2.14.4	Transport properties	271
2.14.6	Further properties	272
	Figures for 2.14	273
	References for 2.14	274
2.15	Indium antimonide (InSb) (Sects. 2.15.1,4,5: A. HANGLEITER; sect. 2.15.6: R. BLACHNIK) . . .	275
2.15.1	Electronic properties	275
2.15.4	Transport properties	275
2.15.5	Optical properties	276
2.15.6	Further properties	276
	Figures for 2.15	277
	References for 2.15	280
2.16	Ternary and quaternary alloys between III-V compounds and with other semiconductors . . .	278
	(Sect. 2.16.1.3: S. ADACHI, with additions of R. BLACHNIK; sects. 2.16.1.4, 2.16.3.3: F. FUCHS, with additions of R. BLACHNIK; remaining sections: A. HANGLEITER, with additions of R. BLACHNIK)	
2.16.1	Ternary alloys of the type $\text{III}_x\text{--III}_{1-x}\text{--V}$	281
2.16.1.3	Aluminum gallium arsenide ($\text{Al}_x\text{Ga}_{1-x}\text{As}$)	281
	Figures for 2.16.1.3	289
	References for 2.16.1.3	302
2.16.1.4	Aluminum gallium antimonide ($\text{Al}_x\text{Ga}_{1-x}\text{Sb}$)	305
	Figures for 2.16.1.4	308
	References for 2.16.1.4	311
2.16.1.5	Aluminum indium phosphide ($\text{Al}_x\text{In}_{1-x}\text{P}$)	311
	References for 2.16.1.5	311
2.16.1.6	Aluminum indium arsenide ($\text{Al}_x\text{In}_{1-x}\text{As}$)	312
	Figures for 2.16.1.6	313
	References for 2.16.1.6	313
2.16.1.7	Aluminum indium antimonide ($\text{Al}_x\text{In}_{1-x}\text{Sb}$)	314
	Figure for 2.16.1.7	314
	References for 2.16.1.7	315
2.16.1.8	Gallium indium phosphide ($\text{Ga}_x\text{In}_{1-x}\text{P}$)	315
	Figures for 2.16.1.8	317
	References for 2.16.1.8	319
2.16.1.9	Gallium indium arsenide ($\text{Ga}_x\text{In}_{1-x}\text{As}$)	320
2.16.1.9.1	Electronic properties	320
2.16.1.9.6	Further properties	322
	Figures for 2.16.1.9	322
	References for 2.16.1.9	323
2.16.1.10	Gallium indium antimonide ($\text{Ga}_x\text{In}_{1-x}\text{Sb}$)	324
	Figures for 2.16.1.10	324
	References for 2.16.1.10	326
2.16.2	Ternary alloys of the type $\text{III--V}_{1-x}\text{--V}_x$	326
2.16.2.4	Indium arsenide phosphide ($\text{InAs}_{1-x}\text{P}_x$)	326
2.16.2.5	Indium antimonide arsenide ($\text{InSb}_{1-x}\text{As}_x$)	326
	Figures for 2.16.2.5	327
	References for 2.16.2.5	327

2.16.2.5a	Indium antimonide phosphide ($\text{InSb}_{1-x}\text{P}_x$)	327
	Figure for 2.16.2.5a	328
	References for 2.16.2.5a	328
2.16.2.5b	Indium arsenide bismuthide ($\text{InAs}_{1-x}\text{Bi}_x$)	328
	Reference for 2.16.2.5b	328
2.16.2.6	Indium antimonide bismuthide ($\text{InSb}_{1-x}\text{Bi}_x$)	328
	Figure for 2.16.2.6	329
	Reference for 2.16.2.6	329
2.16.3	Quaternary alloys of the type $\text{III}_x\text{---III}_{1-x}\text{---V}_y\text{---V}_{1-y}$	329
2.16.3.1	Gallium indium arsenide phosphide ($\text{Ga}_x\text{In}_{1-x}\text{As}_y\text{P}_{1-y}$)	329
	Figures for 2.16.3.1	330
	References for 2.16.3.1	331
2.16.3.2	Gallium indium arsenide antimonide ($\text{Ga}_x\text{In}_{1-x}\text{As}_y\text{Sb}_{1-y}$)	331
2.16.3.3	Aluminum gallium arsenide antimonide ($\text{Al}_x\text{Ga}_{1-x}\text{As}_y\text{Sb}_{1-y}$)	332
	Figures for 2.16.3.3	332
	References for 2.16.3.3	334
2.16.4	Quaternary alloys of the type $\text{III}_{1-x-y}\text{---III}_x\text{---III}_y\text{---V}$	334
2.16.4.1	Aluminum gallium indium phosphide ($\text{Al}_x\text{Ga}_y\text{In}_{1-x-y}\text{P}$)	334
	Figures for 2.16.4.1	336
	References for 2.16.4.1	338
2.16.4.2	Aluminum gallium indium arsenide ($\text{Al}_x\text{Ga}_y\text{In}_{1-x-y}\text{As}$)	338
	Figures for 2.16.4.2	340
	References for 2.16.4.2	341
2.16.4.3	Aluminum gallium indium antimonide ($\text{Al}_x\text{Ga}_y\text{In}_{1-x-y}\text{Sb}$)	341
2.16.4.A	Quaternary alloys of the type $\text{III}\text{---V}_{1-x-y}\text{---V}_y\text{---V}_x$	341
2.16.4.A.1	Indium antimonide arsenide phosphide ($\text{InAs}_{1-x-y}\text{Sb}_y\text{P}_x$)	341
	Figures for 2.16.4.A.1	342
	References for 2.16.4.A.1	343
	Further data for other solid solutions between III–V compounds (only further properties) . . .	343
	References	343
2.17	Ordering effects in ternary and quaternary compounds (A. HANGLEITER)	344
2.17.1	Partially ordered $\text{Al}_{0.51}\text{In}_{0.49}\text{P}$	344
2.17.2	Partially ordered $\text{Ga}_{0.51}\text{In}_{0.49}\text{P}$	344
2.17.3	Partially ordered $\text{Ga}_{0.53}\text{In}_{0.47}\text{As}$	345
2.17.4	Partially ordered $\text{In}_{0.6}\text{AsSb}_{0.4}$	345
	Figures for 2.17	345
	References for 2.17	347