

Index

- (Zn,Cd)O, 13
- (Zn,Mg)O, 13

- absorption edge, fundamental, 111
 - MgZnO, 117, 118
 - temperature, 112–114, 116
- air mass (AM), 250
- Aluminium concentration, 135
- angular distribution function, 287
- anisotropy of conductivity, 48
- atomic layer deposition, 293

- band alignment
 - amorphous interface, 164
 - II–VI semiconductors, 13
 - ZnO/(Zn,Mg)O, 13, 14
- band gap, 274–276
 - shrinkage at high doping level, 276
- band gap engineering, 13
- band gap, fundamental, 109, 111
 - MgZnO, 117, 118
 - temperature, 112–114, 116
- band-to-band transitions, 108, 109
- Bose–Einstein model, 96, 112
 - parameters, 97, 113
- bowing, 117
- brass, 21
- Burstein–Moss effect, 274–276

- cathodoluminescence, 26
- Cauchy formula, 105
 - parameters, 107, 108
- CdO, 5
- CIGS solar cells
 - CVD ZnO buffer layers, 289
- collision cascade, 192
- combinatorial PLD, 347
- conduction band offset, 126

- conductivity
 - of ZnO single crystals, 36
- critical points, 108
 - parameters, 109
 - model dielectric function, 87
- crystal structure, 81
 - rocksalt, 83
 - wurtzite, 82
- crystal-field splitting, 110, 112
- crystallographic structure, 4
- Cu(In,Ga)Se₂
 - Cu depletion, 168
 - influence of Na, 169
 - Se cap layer, 164
 - solar cell, 128
- cubic ZnO, 4
- CVD
 - atmospheric pressure (APCVD), 235, 238, 241
 - deposition temperature, 261
 - grain size, 245, 247
 - growth kinetics, 238, 239
 - low pressure (LPCVD), 239
 - precursors, 236

- damp-heat test, 368
- Debye-temperature, 112–114
- defect annealing, 21
- defects
 - antisites, 14
 - concentration, 15
 - concentration in ZnO, 19
 - formation enthalpy, 15
 - formation enthalpy for ZnO, 16
 - Frenkel, 14, 17
 - in ZnO, 14–23
 - oxygen dumbbell interstitial, 17, 20, 21

- oxygen interstitial, 14
- oxygen split interstitial, 17
- oxygen vacancy, 14, 17, 19, 35, 38
- oxygenvacancies, 38, 39
- Schottky, 14
- self compensation, 18
- transition energies, 18
- zinc interstitial, 14, 19, 35, 38, 39
- zinc vacancy, 14, 17, 18
- demonstrator devices, 336
- density, 6
- dielectric constants, 85, 91, 105
 - MgZnO, 91
 - ZnO, 91
- dielectric function, 89–90
 - ZnO - temperature, 113
 - ZnO - VIS-VUV, 108, 113
- diffusion
 - in ZnO, 19–23
 - migration enthalpy, 19, 21
 - of oxygen in ZnO, 20–22
 - of zinc in ZnO, 21, 23
- doping
 - of CVD ZnO films, 266
- doping efficiency, 18, 203, 249, 257, 272, 273
- doping limits, 18
 - for ZnO and In_2O_3 , 19
- doping uniformity
 - of CVD ZnO films, 257
- droplets, 304

- effective electron mass, 103
- electroluminescence, 26
- electron mobility
 - of AP-CVD ZnO films, 257
 - of CVD ZnO films, 258
- electron-phonon interaction, 112
- electronic structure, 12
- ellipsometry, 81, 88
 - data analysis, 89
 - generalized, 89
 - standard, 88
- energy band diagram, 126
- epitaxial ZnO thin films, 313
 - n*-type doped, 322
 - pn*-junctions, 344
 - p*-type doped, 322, 344
 - AFM, 319
 - applications, 336
 - Bragg reflectors, 340
 - carrier concentration, 323
 - cathodoluminescence, 327, 338
 - chemical composition, 331
 - composition transfer, 334
 - deep level transient spectroscopy, 325
 - demonstrator devices, 336
 - diffusion barrier layer, 322
 - doping, 331
 - electrical properties, 322
 - excitons, 329
 - Hall mobility, 323
 - highlights, 344
 - magnetic domain formation, 337
 - phonons, 329
 - photoluminescence, 327
 - quantum well structures, 340
 - resistivity, 323
 - results of the Leipzig group, 335
 - RHEED, 314
 - Schottky contact, 327, 341
 - scintillators, 338
 - semiinsulating, 323
 - structure, 314
 - surface morphology, 319
 - TEM, 314
 - temperature-dependent Hall effect, 325
 - trace element concentrations, 334
 - XRD, 314
- etching behavior
 - acidic solution, 370, 380, 382, 384, 386
 - alkaline solution, 380, 382, 386
 - discussion, 389
 - influence of aluminum doping, 385
 - influence of deposition pressure, 384
 - influence of glass substrate, 392
 - influence of hidden parameters, 387
 - influence of substrate temperature, 384
 - influence of working point, 386
 - ion beam treatment, 387
 - modified Thornton model, 384
 - plasma etching, 388
 - polycrystalline films, 382
 - single crystal, 380

- etching of sputtered ZnO layers, 213
- excimer laser, 309
- excitons, 108, 109, 111, 113
- Fermi level pinning, 127
 - at CdS/ZnO interface, 160, 164
 - at In₂S₃/ZnO interface, 177
- field effect transistor, 26
- figure of merit, 287
- formation enthalpy, 6, 166
- free-charge-carriers, 80, 86, 102–105
- fundamental absorption edge, 86
- fundamental PLD processes
 - ablation, 306
 - ablation threshold, 308
 - absorption, 306
 - condensation, 308
 - film growth, 308
 - nucleation, 308
 - plasma expansion, 307
- Ga₂O₃, 166
- Grüneisen parameters, 97
- grain boundaries, 59
- grain boundary scattering, 257, 259, 278
- grain size
 - of CVD films, 247
 - of LPCVD films, 245, 247
- growth of ZnO single crystals, 9
- Hall coefficient, 44, 46
- Hall effect, 37
- hidden effects, 310
- high pressure phase, 5
- high-*T_c* superconductor, 303
- high-pressure PLD, 348
- hydrogen, 19
- In₂O₃, 5, 6, 18, 166
- index of refraction, 105
 - birefringence, 106
 - MgZnO, 106, 108
 - temperature, 107
 - ZnO, 106, 108
 - MgZnO, 107
 - temperature, 106
 - ZnO, 107
- interface dipole
 - at In₂S₃/ZnO interface, 177
- ionization potential
 - influence on band alignment, 160
 - of CdS, 144
 - of CdTe, 144
 - of ZnO, 143
- ionized impurity scattering, 257
- ITO, 18, 19, 25, 227
- laser pulse energy, 310
- laser-MBE, 347
- lattice mismatch, 128
- LCAO theory, 12
- LCD display, 25
- light scattering, 369
 - Lambertian scattering, 402
 - of APCVD ZnO, 259
 - of LPCVD ZnO, 259, 260
- light trapping, 369, 370, 375
 - periodic gratings, 376
 - textured glass, 376
 - tin oxide, 375
 - zinc oxide (CVD), 376
 - zinc oxide (texture etched), 376
- low energy ion scattering (LEIS), 133
- Lydanne–Sachs–Teller relation, 85
- magnetic semiconductors, 27
- material properties, 6
- micromorph Si solar cell, 284, 285
- mobility, 38, 42–53, 377
 - as a function of carrier concentration, 49
- model dielectric function, 85–88, 109
 - critical points, 86, 87
 - excitons, 87
 - free charge carriers, 86
 - phonons, 85
 - plasmons, 86
- module
 - encapsulation, 368
- multi-element compounds, 304
- Nd-YAG laser, 309
- nucleation
 - amorphous layer, 155, 164
 - oxygen dissociation, 138
- nucleation layer, 268

- organic LED, 25, 227
- organic solar cells, 227

- p-d repulsion, 12
- peroxide, 7, 17, 138, 153, 154
- phase diagram, 7
- phonons, 83–84, 92–102, 112
 - broadening parameters, 80, 100–102
 - MgZnO, 99–100
 - rocksalt-structure, 84
 - wurtzite-structure, 83
 - ZnO, doped, 98–99
 - ZnO, undoped, 92–96
 - pressure, 96
 - temperature, 95–96
- photoelectron spectroscopy, 128
 - interface studies, 129
 - of ZnO films, 133
 - plasmon excitation, 133, 148, 149
- piezoelectric coefficient, 6
- piezoelectric properties, 1, 26, 213
- plasmons, 80, 86, 102–105
- PLD chamber, 311
- PLD parameters, 312
- pulsed electron beam
 - deposition, 347
- pulsed laser deposition, 303
 - advanced PLD techniques, 346
 - basics, 303
 - demonstrator devices, 336
 - epitaxial ZnO thin films, 313
 - flexibility, 313
 - fundamental processes, 305
 - history, 303
 - instrumentation, 309
 - modelling, 305
 - nanostructures, 348
 - plasma diagnostics, 305
 - ZnO growth parameters, 309

- quantum well structures, 13

- radiation resistance, 21
- Raman scattering, 81, 84
 - scattering configurations, 84
 - selection rules, 85
- residual conductivity, 18, 19

- rocksalt structure, 5
- roll-to-roll process, 366

- sapphire substrate, 313
- SAW devices, 213
- ScAlMgO₄ substrate, 313
- scattering processes
 - acoustical mode scattering, 44
 - dislocation scattering, 57
 - grain boundaries, 59
 - ionized impurity scattering, 45
 - neutral impurity scattering, 48
 - optical mode scattering, 43
 - piezoelectric mode scattering, 44
- Schottky contact, 126
 - of ZnO, 127
- Seebeck coefficient, 38
- segregation, 26
- self compensation, 18
- sheet resistance, 372
- Silicon, 6
- silicon
 - absorption, 369
 - absorption coefficient, 364
 - amorphous silicon, 363
 - band structure, 361
 - bandgap, 364
 - crystalline silicon, 361
 - defects, 362
 - microcrystalline silicon, 363
 - nanocrystalline silicon, 363
 - polycrystalline silicon, 363
- SnO₂, 5, 6
- solar cells
 - J/V*-curve, 362
 - back reflector, 361, 365, 376, 399
 - efficiency, 363, 403, 404
 - fill factor, 362
 - heterojunction, 361
 - internal electric field, 362
 - light induced degradation, *see* Staebler–Wronski effect
 - light trapping, 369, 370, 397
 - module, *see* solar modules
 - n-i-p structure, 361
 - open circuit voltage, 362
 - optical losses, 372
 - optical simulation, 372
 - p-i-n structure, 361

- photo current, 362
- quantum efficiency, 366, 371, 396
- short circuit current, 362
- stability, 367
- structure, 365
- substrate configuration, 365
- superstrate configuration, 365
- tandem structure, 366
- TCO-p contact, 394
- solar modules, 373
 - active area, 374
 - aperture area, 374
 - cell width, 374
 - dead area, 374
 - efficiency, 403
 - encapsulation, 366
 - interconnection area, 374
 - series-connection, 373
- space group, 6
- spin-orbit coupling, 110, 112
- spintronics, 27
- sputter damage, 128
- sputter yield, 190
- Staebler–Wronski effect, 363, 367, 400
- STM of ZnO surfaces, 132, 133
- stoichiometry, 7, 8
 - of sputtered ZnO, 134
- strain, 80, 112, 114
- sublimation, 7
- surface acoustic wave
 - devices, 26, 27
- surface roughness, 247, 248
- surface states
 - of ZnO, 140
- surface structure
 - stability of polar surfaces, 132
 - wurtzite lattice, 132
 - wurtzite(10 $\bar{1}$ 0), 132
 - wurtzite(11 $\bar{2}$ 0), 132
 - zincblende lattice, 132
 - zincblende(110), 132
 - zincblende(111), 132
 - zincblende($\bar{1}\bar{1}\bar{1}$), 133
 - ZnO(0001), -(000 $\bar{1}$), 132, 133
- surface termination, 132, 213
 - of ZnO, 144
- texture
 - of sputtered ZnO films, 132, 144, 145, 157
- thermal conductivity, 6
- thermal expansion, 8
- thermal expansion coefficient, 6
- thermovoltage, 37
- thin film solar cells, 24
- tin oxide, 375
- transparent electrodes, 24
- two-oscillator model, 112, 116
 - parameters, 114
- valence band offset, 126
- valence-band ordering, 110, 112
- vapor pressure, 7
- varistor, 53
- varistors, 25
- Varshni model, 112
 - parameters, 113
- volume deposition rate, 304
- work function
 - of ZnO, 142, 143
- YBa₂Cu₃O_{7- δ} , 303
- zinc oxide
 - C_{Al}, 370
 - doping level, 370
 - electrical properties, 372, 378
 - etching behavior, *see* etching behavior
 - haze, 371
 - optical properties, 369, 370, 378
 - parasitic absorption, 401, 402
 - roughness, 371
 - sputter deposition, 377, 403, 404
 - surface texture, 371, 397
- Zn resources, 3
- Zn₂SiO₄, 26
- ZnGa₂O₄, 26
- ZnO ceramics, 26
- ZnO nanostructures, 11
- ZnO single crystals
 - growth of, 9, 10
- ZnO surfaces, 131–149
- ZnO:Al, *see* zinc oxide

Springer Series in
MATERIALS SCIENCE

Editors: R. Hull R. M. Osgood, Jr. J. Parisi H. Warlimont

- 40 **Reference Materials in Analytical Chemistry**
A Guide for Selection and Use
Editor: A. Zschunke
- 41 **Organic Electronic Materials**
Conjugated Polymers and Low Molecular Weight Organic Solids
Editors: R. Farchioni and G. Grosso
- 42 **Raman Scattering in Materials Science**
Editors: W. H. Weber and R. Merlin
- 43 **The Atomistic Nature of Crystal Growth**
By B. Mutaftschiev
- 44 **Thermodynamic Basis of Crystal Growth**
P-T-X Phase Equilibrium and Non-Stoichiometry
By J. Greenberg
- 45 **Thermoelectrics**
Basic Principles and New Materials Developments
By G. S. Nolas, J. Sharp, and H. J. Goldsmid
- 46 **Fundamental Aspects of Silicon Oxidation**
Editor: Y. J. Chabal
- 47 **Disorder and Order in Strongly Nonstoichiometric Compounds**
Transition Metal Carbides, Nitrides and Oxides
By A. I. Gusev, A. A. Rempel, and A. J. Magerl
- 48 **The Glass Transition**
Relaxation Dynamics in Liquids and Disordered Materials
By E. Donth
- 49 **Alkali Halides**
A Handbook of Physical Properties
By D. B. Sirdeshmukh, L. Sirdeshmukh, and K. G. Subhadra
- 50 **High-Resolution Imaging and Spectrometry of Materials**
Editors: F. Ernst and M. Rühle
- 51 **Point Defects in Semiconductors and Insulators**
Determination of Atomic and Electronic Structure from Paramagnetic Hyperfine Interactions
By J.-M. Spaeth and H. Overhof
- 52 **Polymer Films with Embedded Metal Nanoparticles**
By A. Heilmann
- 53 **Nanocrystalline Ceramics**
Synthesis and Structure
By M. Winterer
- 54 **Electronic Structure and Magnetism of Complex Materials**
Editors: D.J. Singh and D. A. Papaconstantopoulos
- 55 **Quasicrystals**
An Introduction to Structure, Physical Properties and Applications
Editors: J.-B. Suck, M. Schreiber, and P. Häussler
- 56 **SiO₂ in Si Microdevices**
By M. Itsumi
- 57 **Radiation Effects in Advanced Semiconductor Materials and Devices**
By C. Claeys and E. Simoen
- 58 **Functional Thin Films and Functional Materials**
New Concepts and Technologies
Editor: D. Shi
- 59 **Dielectric Properties of Porous Media**
By S.O. Gladkov
- 60 **Organic Photovoltaics**
Concepts and Realization
Editors: C. Brabec, V. Dyakonov, J. Parisi and N. Sariciftci
- 61 **Fatigue in Ferroelectric Ceramics and Related Issues**
By D.C. Lupascu
- 62 **Epitaxy**
Physical Principles and Technical Implementation
By M.A. Herman, W. Richter, and H. Sitter
-

Springer Series in
MATERIALS SCIENCE

Editors: R. Hull R. M. Osgood, Jr. J. Parisi H. Warlimont

- 63 **Fundamentals of Ion-Irradiated Polymers**
By D. Fink
- 64 **Morphology Control of Materials and Nanoparticles**
Advanced Materials Processing and Characterization
Editors: Y. Waseda and A. Muramatsu
- 65 **Transport Processes in Ion-Irradiated Polymers**
By D. Fink
- 66 **Multiphased Ceramic Materials**
Processing and Potential
Editors: W.-H. Tuan and J.-K. Guo
- 67 **Nondestructive Materials Characterization**
With Applications to Aerospace Materials
Editors: N.G.H. Meyendorf, P.B. Nagy, and S.I. Rokhlin
- 68 **Diffraction Analysis of the Microstructure of Materials**
Editors: E.J. Mittemeijer and P. Scardi
- 69 **Chemical–Mechanical Planarization of Semiconductor Materials**
Editor: M.R. Oliver
- 70 **Applications of the Isotopic Effect in Solids**
By V.G. Plekhanov
- 71 **Dissipative Phenomena in Condensed Matter**
Some Applications
By S. Dattagupta and S. Puri
- 72 **Predictive Simulation of Semiconductor Processing**
Status and Challenges
Editors: J. Dabrowski and E.R. Weber
- 73 **SiC Power Materials**
Devices and Applications
Editor: Z.C. Feng
- 74 **Plastic Deformation in Nanocrystalline Materials**
By M.Yu. Gutkin and I.A. Ovid'ko
- 75 **Wafer Bonding**
Applications and Technology
Editors: M. Alexe and U. Gösele
- 76 **Spirally Anisotropic Composites**
By G.E. Freger, V.N. Kestelman, and D.G. Freger
- 77 **Impurities Confined in Quantum Structures**
By P.O. Holtz and Q.X. Zhao
- 78 **Macromolecular Nanostructured Materials**
Editors: N. Ueyama and A. Harada
- 79 **Magnetism and Structure in Functional Materials**
Editors: A. Planes, L. Mañosa, and A. Saxena
- 80 **Micro- and Macro-Properties of Solids**
Thermal, Mechanical and Dielectric Properties
By D.B. Sirdeshmukh, L. Sirdeshmukh, and K.G. Subhadra
- 81 **Metallopolymer Nanocomposites**
By A.D. Pomogailo and V.N. Kestelman
- 82 **Plastics for Corrosion Inhibition**
By V.A. Goldade, L.S. Pinchuk, A.V. Makarevich and V.N. Kestelman
- 83 **Spectroscopic Properties of Rare Earths in Optical Materials**
Editors: G. Liu and B. Jacquier
- 84 **Hartree–Fock–Slater Method for Materials Science**
The DV–X Alpha Method for Design and Characterization of Materials
Editors: H. Adachi, T. Mukoyama, and J. Kawai
- 85 **Lifetime Spectroscopy**
A Method of Defect Characterization in Silicon for Photovoltaic Applications
By S. Rein
- 86 **Wide-Gap Chalcopyrites**
Editors: S. Siebentritt and U. Rau
- 87 **Micro- and Nanostructured Glasses**
By D. Hülsenberg and A. Harnisch
-