

## Index

### a

- $A'A''B_2O_{5+\delta}$  112, 113  
 $A_2B'B''O_6$  ( $Sr_2FeMoO_6$ ) 112–115  
 acoustic mismatch model (AMM) 41  
 advanced bulk technology 214–217  
   hot-press sintering 215–216  
   microwave sintering 217–218  
   phase transformation sintering 219  
   spark plasma sintering 215  
   two-step sintering technique 218–219  
 Al-doped ZnO bulk material (AZO) 216  
 Al-doped ZnO rods 84, 85  
 Al-doped ZnO samples 81  
 alkali and alkali-earth metal ions 141  
 all-oxide thermoelectric devices 242–245  
 Apollo-12 229  
 as-prepared SnSe nanosheet/  
   PEDOT:PSS composites 200

### b

- Ba-filled skutterudites 60  
 ball-milled n-type SiGe alloys 64  
 band gap tuning 167, 168  
 barrier energy 21  
 benzenesulfonic acid (BSA) 189  
 Bergman's theorem 179  
 $Bi_{0.875}Ba_{0.125}CuSeO$  169  
 BiCuSeO-based materials 164  
 BiCuSeO-BiCuTeO compositing 168  
 BiCuSeO oxyselenides 7, 166  
 bi-doping 139  
 $[Bi_2O_2]^{2+}$  layers 158

- $Bi_2O_2Se_{1-x}Cl_x$  ceramics 162  
 $Bi_2O_2Se_{1-x}Te_x$  samples 161  
 $Bi_{0.5}Sb_{1.5}Te_3$  58  
 $Bi_{1.9}Sn_{0.1}O_2Se$  sample 158  
 $Bi_2Sr_2Co_2O_9$  polycrystalline materials 150  
 $Bi_2Sr_2Co_2O_x$  (BSC-222) bulk materials 151  
 $Bi_2Sr_2Co_2O_y$  133  
 $Bi_2Te_3$  155  
 $Bi_2Te_3$ -based materials 55–59  
 $Bi_2Te_3/Sb_2Te_3$  superlattices film 57  
 $Bi_2Te_3$  thermoelectric materials 254  
 $Bi_2Te_3/TiO_2$  composite photoanode 254  
 $Bi_{1-x}La_xCuSeO$  ceramic bulks 168  
 Boltzmann constant 11, 31  
 Boltzmann equation 36–37  
 Boltzmann transport equation (BTE) 11  
 bonding and lattice vibration 25  
 brick-and-mortar-type nanoscale ceramic 183  
 Bridgman and Czochralsky method 55
- ### c
- $Ca_3Co_4O_9$  (CCO) 138  
   charge and spin-state of Co ion 139  
   dual-dopants 144–146  
   single dopant of 139–144  
   spin-entropy contribution 139  
   texture 147  
 $Ca_3Co_4O_9$  133  
 $Ca_3Co_{4-x}TM_xO_{9+\delta}$  139

- $\text{Ca}_3\text{Co}_{4-y}\text{Fe}_y\text{O}_9$  144–146  
 $\text{Ca}_2\text{FeMoO}_6$  115  
 $\text{CaMn}_{0.98}\text{Nb}_{0.02}\text{O}_3$  243  
 $\text{CaMnO}_3$  109  
 camphorsulfonic acid (CSA) 189  
 $\text{Ca}_{3-x}\text{Tb}_x\text{Co}_4\text{O}_9$  142  
 $\text{Ca}_{0.9}\text{Yb}_{0.1}\text{MnO}_3$  122, 214  
 $\text{CdI}_2$ -type  $[\text{CoO}_2]$  sheet 133  
 $\text{CdO}$  3, 99  
 $\text{CdTe}/\text{Bi}_2\text{Te}_3/\text{FTO}$  photoelectrode  
     254  
 centrosymmetrical perovskite 106  
 $\text{CeO}_2$  nanodots 96  
 ceramics 3, 4, 7, 8, 95, 109, 122, 146,  
     147, 168, 173–175, 183, 212–215,  
     217–221  
 Clevios PEDOT products 186  
 Co-based oxide material  $\text{Ca}_3\text{Co}_4\text{O}_9$  7  
 co-doping 190  
 coefficient of thermal expansion (CTE)  
     233  
 cold isostatic pressing (CIP) 214  
 column or cube-like n-type and p-type  
     TE elements 232  
 commercially available ZnO  
     nanoparticles 82  
 complex oxides 155–175  
     complexity through disorder in the  
         unit cell 173–174  
     complex superconductors 156–157  
     complex unit cells 174–175  
     crystal structure and property  
         relationship 155–156  
     quaternary oxyselenides 164–166  
     ternary oxyselenides 158–164  
 complex superconductors 156–157  
 complex unit cells 174–175  
 composite ceramics 118–120  
 conducting oxides 3–8, 11, 87, 150  
 conduction band (CB) 32, 45,  
     107–109, 162, 168, 183, 188,  
     237  
 conduction band minimum (CBM)  
     108, 183  
 Cu-based bulk thermoelectric materials  
     70  
 cubic zinc blende (B3) 77  
 $\text{Cu}_2\text{Ga}_x\text{Sn}_{1-x}\text{Se}_3$  bulks 216  
 $\text{CuInGaSe}_2$  (CIGS) PV cells 252  
 $\text{Cu}_2\text{Se}_x$  nanodots 171, 181  
 $\text{Cu}_7\text{Te}_{4-x}\text{Se}_x$  nanoinclusions 171, 181
- d**
- Debye–Callaway model 31, 44, 46, 182  
 de-doping 190  
 density function theory (DFT) 11, 89  
 density of dislocation 26  
 diffuse mismatch model (DMM)  
     41, 43  
 digital multimeter (DMM) 244  
 dodecylbenzenesulfonic acid (DBSA)  
     189  
 dominant phonon method 35  
 donor doping  
     on  $[\text{Bi}_2\text{O}_2]^{2+}$  layers 158–160  
     on  $[\text{Se}]^{2-}$  layers 160  
 doped-PEDOT system 186  
 double perovskites  
     composite ceramics 118–120  
     doping modulation 115–118  
     structure of 112–113  
     thermoelectric properties of  
          $\text{A}_2\text{B}'\text{B}''\text{O}_6$  113–115  
 DSSC/SSA/TE hybrid equipment 250,  
     251  
 dual doping of ZnO 83  
 Dulong–Petit’s law 156  
 dye-sensitized solar cells (DSSCs) 247
- e**
- edge-free spark plasma sintering 147  
 electrical properties 3, 11–15, 18, 32,  
     81, 89–90, 107, 109, 120,  
     155–157, 160, 165, 175, 219, 220,  
     236  
 energy-filtering effect 179, 180, 196
- f**
- Fe–Cr alloy 238  
 Fe-doped  $\text{Ca}_3\text{Co}_{4-y}\text{Fe}_y\text{O}_9$  144, 146  
 Fermi–Dirac integrals 15  
 Fermi energy 11, 13, 27, 32, 57, 173,  
     237  
 Fermi’s golden rule 38

- four-element BiCuSeO 171  
 four-leg thermoelectric all oxide module 243
- g**  
 gas phase reaction (GPR) 122, 214  
 GdBaCuFeO<sub>5+δ</sub> 116, 175  
 Gd-doped Ca<sub>3</sub>Co<sub>4</sub>O<sub>9</sub> p-type legs 243  
 Gd-doped CMO 35  
 Gd<sub>1-x</sub>La<sub>x</sub>BaCuFeO<sub>5+δ</sub> 116  
 Goldschmidt tolerance Factor 106  
 grain-aligned dense Ca<sub>3</sub>Co<sub>4</sub>O<sub>9</sub>-based ceramics 147  
 grain boundaries (GBs) 25, 35, 44, 48, 49, 56, 58, 59, 65, 66, 69, 93, 94, 96, 116, 118, 120, 122, 160, 175, 183  
 Gruneisen constant 45  
 Grüneisen parameter 26, 31, 67, 166  
 G-type anti-ferromagnetic phase CaMnO<sub>3</sub> system 107
- h**  
 Harman method 242  
 heat conduction 34, 60, 156, 230, 231  
 heavily doped bulk n-type SiGe alloys 180  
 heavily doped p-GaAs 252  
 hexagonal wurtzite (B4) 8, 77, 78  
 hierarchically microstructured Bi<sub>0.96</sub>Pb<sub>0.04</sub>CuSe<sub>1-x</sub>Te<sub>x</sub>O 181  
 highly dispersed nanosized closed pores 81  
 highly efficient phonon scattering 166  
 high performance thermoelectric oxyselenide BiCuSeO ceramics 7  
 high-temperature Seebeck coefficient 16  
 high temperature superconductors 3, 156  
 homogeneous composite 179  
 hot-press sintering 215–217  
 hydride vapor phase epitaxy (HVPE) 26  
 hydrothermal synthesis 84, 213
- i**  
 indium tin oxide (ITO) 3  
 In<sub>1.92</sub>(Ce, Zn)<sub>0.08</sub>O<sub>3</sub> 94  
 In<sub>2</sub>O<sub>3</sub> 87  
   crystal structure 88–89  
   doping 90–93  
   electronic band structure 89  
   nanostructures 94–98  
   thermal properties and electrical properties 89–90  
 In<sub>2</sub>O<sub>3</sub>-based and BiCuSeO-based ceramics 32  
 In<sub>2</sub>O<sub>3</sub>-based thermoelectric ceramics 217  
 in-situ polymerized PEDOT+tos films 186  
 in-situ SrTe precipitate 66  
 interface potential 20, 22  
 interfacial thermal conductivity 40–43  
 intrinsic Umklapp process 47, 95
- j**  
 Joule heat 230, 231, 239, 242  
 J-V characteristic curve 250
- k**  
 Kapitza resistance 41  
 kinetic theory 36  
 (K,Na)NbO<sub>3</sub>-based ceramics 219  
 Kohn anomaly 27
- l**  
 LaBaCu<sub>0.9</sub>Co<sub>0.1</sub>FeO<sub>5+δ</sub> 117  
 LaBaCuFeO<sub>5+δ</sub> 113, 117  
 LaCoO<sub>3</sub> 111  
 La<sub>2</sub>CuO<sub>4</sub> 157  
 LaCuSeO-BiCuSeO solid solution 168  
 La-doped CaMnO<sub>3</sub> n-type legs 243  
 La-doped SmBaCuFeO<sub>5</sub> polycrystalline ceramics 175  
 LaFeAsO 3  
 (La, Fe) co-doped Ca<sub>3-x</sub>La<sub>x</sub>Co<sub>4-y</sub>Fe<sub>y</sub>O<sub>9</sub> 144–146  
 LaFeO<sub>3</sub> nanocrystals 209  
 La-filled skutterudites 60  
 La<sub>1.96</sub>M<sub>0.04</sub>CuO<sub>4</sub> 157

- lanthanide elements doped  $\text{Ca}_3\text{Co}_4\text{O}_9$   
141
- La-substituted  $\text{GdBaCuFeO}_{5+\delta}$  ceramics  
175
- lattice distortions  
  octahedral distortion 28–30  
  Peierls distortion 27–28  
  point defects and dislocations  
    25–27
- lattice thermal conductivity  
  Boltzmann equation 36–37  
  kinetic theory 36  
  phonon-phonon collisions 38–40
- Li-doped  $(\text{K},\text{Na})\text{NbO}_3$  ceramics 219
- lightly doped  $n$ -GaAs 252
- lithium lanthanum titanates 3
- Lorenz number 13–15
- low-energy grain boundaries 58
- m**
- macromolecular protonic acid doping  
189
- Magnéli phase titanium oxides 99
- manganite perovskites 28–30
- material-level solar energy 253
- Mathiessen's rule 17
- microwave sintering 217–218
- minimum values for oxides 48
- misfit-layered cobaltites ( $\text{Ca}_3\text{Co}_4\text{O}_9$ )  
9, 133, 138
- modulation-doped  
   $(\text{Si}_{95}\text{Ge}_5)_{0.65}(\text{Si}_{70}\text{Ge}_{30}\text{P}_3)_{0.35}$  65
- modulation doping (MD) 64, 65,  
169–171
- molecular dynamics simulation 43
- mosaic blocks 69
- mosaic crystal 69, 70
- Mott–Schottky theory 237
- n**
- $\text{NaCo}_2\text{O}_4$ -based TE materials 238
- $\text{NaCo}_2\text{O}_4$  nanocrystals 256
- $\text{NaCo}_2\text{O}_4/\text{TiO}_2$  coaxial nanofibers 260
- N and Nb codoped  $\text{TiO}_2$  powders 99
- nano bulk materials 43–48
- nanocomposites 17, 18, 147  
  design  
    all-scale hierarchical architecture  
      181–183  
    energy filtering 180  
    quantum nanostructured bulk  
      materials 183
- nano compositing 171
- nanocrystallites 69
- nano-grained  $\text{In}_2\text{O}_3$ -based bulks 47
- nanograins 47, 48, 70, 95, 97, 120, 121,  
171
- nanoinclusions 17, 20  
  ZnO 97
- nano-powder  
  gas phase reaction 214  
  hydrothermal synthesis 213–214  
  precipitation or coprecipitation  
    method 211–213  
  sol-gel (solution-gelation) method  
    211  
  solid-state reaction 209–210
- nanosized LSCO particles 149
- nanostructured bulk  $\text{Bi}_x\text{Sb}_{2-x}\text{Te}_3$  alloys  
56
- nanovoids 81
- nanowire arrays 56, 213
- narrow-gap  $\text{Bi}_2\text{O}_2\text{Te}$  160
- $\text{Na}_x\text{CoO}_2$  105, 109, 133–138
- Nb-doped STO 109
- $(\text{Na}_{0.5}\text{K}_{0.5})\text{NbO}_3$  (NKN) ceramics 220
- NiO 238
- nominally undoped ZnO 81
- non-oxides materials  
   $\text{Bi}_2\text{Te}_3$ -based materials 55–59  
  other alloy materials 66–70  
  Si-Ge alloys 62–66  
  skutterudite-based material 59–62
- non-oxide thermoelectric devices 242
- n-type Ba-filled skutterudites  
   $\text{Ba}_y\text{Co}_4\text{Sb}_{12}$  60
- n-type  $\text{Bi}_2(\text{Te},\text{Se})_3$  55
- n-type CdO 99
- n-type- $\text{In}_2\text{O}_3$  88
- n-type SiGe 64
- n-type thermoelectric materials 192
- n-type titanium dioxide 259
- n-type zinc oxide 77

**O**

- octahedral distortion 28–30
- Ohmic contact 236, 237
- 1D nanowires/nanotubes/polymer 193–197
- organic-inorganic thermoelectric nanocomposites
  - 1D nanowires/nanotubes/polymer 193–197
  - 2D nanosheets/polymer 197–200
  - 0D nanoparticles/polymer 192–193
- organic thermoelectric materials
  - n-type 192
  - PANI 187–189
  - PEDOT 184–187
  - p-type 184
- O vacancy  $V_O$  81
- oxide-based thermoelectric materials 155, 171, 193
- oxide cobaltates
  - $Ca_3Co_4O_9$  138–149
  - $Na_xCoO_2$  133–138
  - new concepts for oxide cobaltites 150–151
- effect of the addition for sintering 220–221
  - gas phase reaction 214
  - hot-press sintering 215–217
  - hydrothermal synthesis 213–214
  - microwave sintering 217–218
  - phase transformation sintering 219
  - precipitation or coprecipitation method 211–213
  - sintering atmosphere 220
  - sintering temperature effect 219–220
  - sol-gel (solution-gelation) method 211
  - solid-state reaction 209–210
  - spark plasma sintering 215
  - two-step sintering technique 218–219
- oxides 3
  - band structure 11
  - effect of interface on electron transport 17–22
  - electrical properties 11–15

- history of 3–8
- minimum values for 48–49
- structural characters of 8–11
- thermoelectric 15–16
- oxygenated TE materials 237

**P**

- PANi/graphene 198
- PANI/Te hybrid film 196, 198
- Pauling ionic radius of atom 26
- PbTe 66, 67, 155
- PbTe-based all-scale nanocomposites 69
- Pb/Te co-doping 181
- Peierls distortion 27–28
- Peltier cooling 239
- Peltier heat 230, 231
- Perovskite type oxides
  - $CaMnO_3$  109–111
    - crystal structure 106–107
    - double 112–120
    - electronic structure 107–108
  - $LaCoO_3$  111
    - nanostructure property relationships 120–124
    - special oxygen octahedron structure 105
  - $SrTiO_3$  108–109
- phase transformation sintering 219
- phonon frequency 25, 26, 31
- phonon-glass electron crystal (PGEC) 60
- phonon occupation number 36
- phonon-phonon collisions 36, 38–40
- phonon relaxation time 26
- phonon scattering rate 25, 26
- photoelectric conversion efficiency (PCE) 248
- photoelectric-thermoelectric composite materials 253–260
- photovoltaic-thermoelectric integration devices 248
- P3HT– $Bi_2Te_3$  interfacial potential barrier diagram 196
- Pioneer F/10 229
- $\pi$ -shaped module 232
- $\pi$ -shaped TE module 233

- Planck's constant 31
- point defects and dislocations 25–27
- Poisson ratio 26
- poly(2,7-carbazole) 184
- poly(3,4-ethylenedioxythiophene) (PEDOT) 184
- polyactylene (PA) 184
- polyaniline (PANI) 184
- classical chemical oxidation polymerization method 188–189
  - conductive mechanism 188
  - doping 189–190
  - electrochemical polymerization method 189
  - emulsion polymerization method 189
  - microemulsion polymerization 189
  - molecular structure 188
- polycrystalline  $\text{Ca}_3\text{Co}_4\text{O}_9$  bulks 142
- polycrystalline  $\text{GdCo}_{0.95}\text{Ni}_{0.05}\text{O}_3$  243
- polymer/graphene nanocomposites 197
- polymer TE materials 179, 192
- poly(3,4-ethylenedioxythiophene):
- poly(styrenesulfonate) and/or polyvinyl acetate composites 194
- polypyrrole (PPY) 184
- poly(3,4-ethylenedioxythiophene)–reduced graphene oxide (PEDOT-rGO)nanocomposite 198
- polythiophene (PTH) 184
- Pr-doped ZnO 82
- precipitation or coprecipitation method 211
- pristine  $\text{Bi}_2\text{O}_2\text{Se}$  160
- projector-augmented wave technique 11, 89
- PSS doped PEDOT film 186
- p-toluenesulfonic acid (TSA) 189
- p-type  $\text{NaCo}_2\text{O}_4$  256, 259, 260
- p-type organic thermoelectric materials 184
- p-type oxide TE materials 7, 108
- p-type PbTe 66
- p-type SiGe (boron doped) alloy 63
- p-type  $(\text{Bi,Sb})_2\text{Te}_3$  55
- p-type thermoelectric semiconductor 259
- pulsed laser deposition (PLD) 173, 220
- pure  $\text{TiO}_2$  nanocrystalline photoanodes 256
- PV-TE (photovoltaic-thermoelectric) based hybrid system 248
- PV-TE mixing device 249
- PV-TE mixing equipment 251
- ## q
- quantum confinement effect 57, 94, 95, 179
- quantum nanostructured bulk materials 183
- quaternary oxyselenides 164
- band gap tuning 168
  - electronic structures 165
  - Hall coefficient 165
  - modulation doping 169–171
  - nanocompositing 171–173
  - Seebeck coefficient 165
  - texturing 168–169
  - thermoelectric properties 166–167
- ## r
- radio-isotope thermoelectric generators (RTGs) 63
- $\text{RBaCuFeO}_{5+\delta}$  113
- $\text{RE}_2\text{CuO}_4$  157
- reduced Fermi level 12
- Rietveld refinement 85, 90, 91
- rocksalt (or Rochelle salt) (B1) 8, 77
- ## s
- Sb-doped ZnO micro/nanobelt nanogenerator 86
- Sb-icosahedron voids 59
- Schottky contact 236, 237
- Seebeck coefficient 4, 7, 11, 13–21, 65, 77, 93, 98, 111, 122, 133, 135, 138, 139, 141, 142, 145, 146, 150, 158, 173, 175, 179, 180, 186, 187, 192, 242, 248

- Seebeck electromotive force 230, 242  
 segmented TE modules 239  
 [Se]2-layers 160  
 self-propagating high temperature synthesis (SHS) 171, 210  
 semicoherent grain boundaries 58  
 short-circuit current density 256  
 short-wavelength phonons 120–121  
 Si-Ge alloys 62–66  
 silicides 63  
 single-branch polarization-averaged velocity 26  
 single-layer MoS<sub>2</sub> and MoS<sub>2</sub> nanoribbons 198  
 single parabolic band model (SPB) 156  
 single Sb-doped ZnO microbelt 86  
 single-walled carbon nanotubes 194  
 sintered polycrystalline sample 80  
 sintering atmosphere 81, 220  
 sintering temperature effect 219  
 skutterudite-based material 55, 59–62  
 skutterudites 59, 60, 63, 193  
 skutterudite TE materials 237  
 small molecular proton acid doping 189  
 small polaron conduction model 16  
 small polaron hopping  
   conduction theory 160  
   mechanism 162  
 SmBaCuFeO<sub>5+δ</sub> 117, 175  
 SmBaCuFe<sub>1-x</sub>CoxO<sub>5+δ</sub> 119  
 SmBaCu<sub>1-x</sub>Co<sub>x</sub>FeO<sub>5+δ</sub> 119  
 Sm<sub>1-x</sub>La<sub>x</sub>BaCuFeO<sub>5+δ</sub> 115  
 Sn doped In<sub>2</sub>O<sub>3</sub> (ITO) 87  
 SnSe 67  
   nanosheets 200  
 solar selective absorber (SSA) 249  
 sol-gel (solution-gelation) method 211  
 solid solution of Bi<sub>2</sub>O<sub>2</sub>Se and Bi<sub>2</sub>O<sub>2</sub>Te 160  
 solid-state reaction 35, 122, 142, 171, 209–210  
 spark plasma sintering 56, 84, 141, 147, 215  
 spark plasma texturing (SPT) 147  
 specific heat 33, 36, 37, 80  
 Sr<sub>2</sub>FeMoO<sub>6</sub> 112  
 SrTiO<sub>3</sub> 108, 109  
 Sr<sub>1-x</sub>Mn<sub>x</sub>TiO<sub>3</sub> ceramics 220  
 STO epitaxial films 109  
 strontium titanate (SrTiO<sub>3</sub>) 8, 108  
 sulfosalicylic acid (SSA) 189  
 superlattice thin films 56  
 SWNTs/PANI composite TE materials 194
- t**
- Ta-doped strontium titanates 109  
 TE cooler (TEC) 229  
 TE generator (TEG) 229, 251  
 tellurides 63, 196  
 TE module efficiency 235  
 ternary oxyselenides  
   donor doping on [Bi<sub>2</sub>O<sub>2</sub>]<sub>2</sub>+ layers 158–160  
   donor doping on [Se]2-layers 160  
   solid solution of Bi<sub>2</sub>O<sub>2</sub>Se and Bi<sub>2</sub>O<sub>2</sub>Te 160–164  
 textured n-type Zn<sub>0.98-x</sub>Al<sub>0.02</sub>Ni<sub>x</sub>O bulks 84  
 thermal boundary resistance (TBR) 41, 48, 120  
 thermal conductivities 26, 28, 48, 49, 62, 80, 216  
 thermal conductivity of nano bulk materials  
   lattice 36  
   lattice distortions 25–30  
   temperature relationship 32–35  
 thermal expansion coefficients 79  
 thermoelectric Bi<sub>2</sub>Te<sub>3</sub> power generation process 254  
 thermoelectric (TE) devices 229  
   all-oxide thermoelectric devices 242–245  
   interfaces 236–238  
   measurement theories and systems 241–242  
   model design 232–236  
   simulation and optimization 238  
   theoretical analysis 230–232  
 thermoelectric generator (TEG) 229, 248, 253, 254

- thermoelectric oxide module (TOM)  
243
- thermoelectric oxides 15, 47, 243,  
259
- thermoelectric-photoelectric composite  
nanocable (CNC) 256
- thermoelectric Seebeck effect 257
- Thermo Microscope's SThM Discoverer  
system 26
- thin-film thermoelectric materials  
57
- Thomson heat 230
- three-phonon processes 38, 39
- $\text{Ti}_{0.94}\text{Nb}_{0.06}\text{O}_2$  thin film 98
- tin-doped  $\text{In}_2\text{O}_3$  88
- $\text{TiO}_2$ - $\text{NaCo}_2\text{O}_4$  composite nanocables  
256
- $\text{TiO}_2$ - $\text{NaCo}_2\text{O}_4$  nanocrystals 257,  
258
- titania- $\text{AlCo}_2\text{O}_4$  composite nanocable  
259
- titanium dioxide ( $\text{TiO}_2$ ) 98–100
- titanium dioxide- $\text{NaCo}_2\text{O}_4$  CNCs 260
- tosylate doped PEDOT film 186
- transition-metal-oxide 16
- transition metals (TM) 8, 59, 60,  
111–113, 139, 141
- transparent conducting oxide 3, 87
- triple rock-salt-type  $[\text{Ca}_2\text{CoO}_3]^{\text{RS}}$  133
- 2D carrier quantum-confinement effects  
57
- 2D nanosheets/polymer 197–200
- two-step sintering technique 218–219
- 2-1-4 type layered rare earth copper  
oxides 157
- u**
- Umklapp process 31, 34, 38–40, 46, 95,  
156
- undoped  $\text{BiCuSeO}$  167
- undoped  $\text{In}_2\text{O}_3$  93, 96
- unfilled skutterudites 59
- urea ( $\text{CO}(\text{NH}_2)_2$ ) 99
- v**
- valence band (VB) 45, 107, 108, 161,  
162, 165, 167, 168, 188, 237
- valence band maximum (VBM) 108,  
165
- Vergard formula 91, 92
- Viking-1 229
- w**
- waste heat 3, 155, 248, 254
- Wiedemann–Franz law 179
- work function (WF) 190–191, 196,  
236, 237
- wurtzite GaN films 26
- wurtzite structure ZnO 8
- y**
- $\text{YBaCuFeO}_{5+\delta}$  117
- z**
- 0D nanoparticles/polymer 192–193
- zinc blende ZnO 8
- zinc oxide (ZnO) 8, 77, 80, 98, 211
- applications 77
- doping 81–84
- electrical properties 81
- electronic band structure 77–78
- lattice parameters 77
- mechanical properties 79
- nanostructures 84–87
- specific heat 80
- structure 77
- thermal conductivities 80
- thermal-expansion coefficients  
79–80
- $\text{Zn}_{0.9975}\text{Bi}_{0.0025}\text{O}$  81
- Zinc oxides 98
- Zn interstitial  $\text{Zn}_i$  81
- ZnO nanorods 209, 210, 213
- ZnO nanowires (NW) 253
- Zn-on-O antisite  $\text{Zn}_\text{O}$  81
- ZnO NWs/CIGS PV device 253
- zone melting 55