

Index

a

absorbed photon-to-current efficiency (APCE) 341
 absorption coefficient 8, 9
 absorption cross section 337
 absorption edge 9
 acceptor 15, 17
 adiabatic process 167
 adiabatic reaction 134, 146
 $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}$ 330
 amorphous (porous) silicon 277
 analysis of electrochemical photovoltaic cells 383–385
 Anderson–Newns model 157
 anodic dissolution 200
 application of a microwave signal 81
 atomic force microscopy (AFM) 87
 atomic force microscopy (TEM-AFM) 417
 attenuated total reflection (ATR) 84

b

band pinning 209
 band structure 5, 6, 13
 band structure of solids 4
 bandgap (eV) 441
 bandgap energy 10
 band-to-band transition 8, 249
 – direct transition 9
 – indirect transition 9
 barrier height 26, 29
 biexciton 336
 black dye 388
 Bloch theorem 5
 Brillouin zone 5, 6
 Burstein shift 319
 Butler–Volmer equation 174
 Butler–Volmer relation 173

c

carrier cooling dynamics 328, 329
 carrier density 11
 carrier multiplication XI, 395
 carrier thermalization 328
 catalysis of electrode reactions 262
 catalyst 262, 308, 404
 Cd_3As_2 295
 CdS 112, 249, 279, 281, 298, 302, 306, 308, 324, 350, 420, 434
 CdS membrane 312
 CdSe 300, 303, 306, 332, 385
 cell performance of DSCs 391
 cell voltage 56
 charge distribution 94
 charge transfer processes 169, 306
 – at metal electrodes 169
 charge transfer resistance 72, 74, 203–205
 chemical potential 23
 – and free energy 54
 – of electrons 55
 – of ions 53, 56
 chemiluminescence 376
 chlorophyll monomolecular layer 359
 co-catalyst 417
 collection of excitons 340
 competition between redox reaction and anodic dissolution 288
 conduction band 5, 6, 12
 conductivity
 – equivalent conductivity 50
 contact potential 26
 continuity equation 251, 253, 390, 392
 conversion efficiencies for photoelectrolysis cells 412
 conversion efficiency 382, 384, 397
 corrosion 267, 288
 – energetics and thermodynamics 285
 crystalline quantum film 303

- CuInSe₂ 386
 current-doubling effect 244, 324
 current-potential curve 189, 198, 200
 current-voltage behavior of dye-sensitized cells (DSCs) 390
- d**
- decomposition of semiconductors 267, 283
 – anodic dissolution reactions 267
 – cathodic dissolution 283
 degenerated semiconductor 17
 density of energy states 12–14, 304
 density-functional theory (DFT) 415
 diffusion coefficient
 – of electrons 18
 – of holes 18
 diffusion constant 51
 diffusion equation 195
 diffusion-controlled process 178, 205
 direct bandgap transition 211
 dissolution current 68
 donor 15–17
 dye-sensitized solar cell (DSC) 386
- e**
- effective mass 6, 15, 32, 298, 441
 effective mass model 300
 electrochemical deposition of metals on semiconductors 123
 electrochemical photovoltaic cell 379–381, 412
 electrochemical potential 53–55, 138
 – of electrons 55, 139
 electrode potential 60
 electrode preparation 65
 electrode side (EE) 391
 electroluminescence 249, 250, 255, 294
 electron density 15, 17
 electron effective mass 303
 electron injection from a dye into a semiconductor 372
 electron transfer 143
 electron transfer in the inverted region 222
 electron transfer rate constant 128
 electron transfer theory 127, 156, 176
 – Gerischer theory 138, 176
 – Levich–Dogonatzte theory 149
 – Marcus theory 127, 128, 222
 – Nozik–Smith treatment 167
 – Schmickler's treatment for metal electrodes 157
 electron tunneling 368
 electron velocity 31
 electron–hole pairs (EHP) 420
- energetics of charge transfer processes 186
 energy bands at the surface 117
 energy gap 5, 6
 energy level 297, 298, 304, 327, 335
 energy levels in nanoparticles 297, 298
 energy levels of molecules 343
 – singlet state 343
 – triplet state 343
 energy states in solution 138
 energy transfer 354
 equivalent circuit 73, 74
 etching of semiconductors 431
 – chemical 431
 – electrochemical 431
 – photoetching 431
 excited molecule 344
 – produced by light excitation 344
 – production by electron transfer 376
 exciton 10, 298, 320
 exciton radius 297
 external quantum efficiency (EQE) 391, 395
- f**
- fabrication of dye-sensitized cells (DSC) 387
 Faraday impedance 77
 Fermi distribution 14, 16
 Fermi level 14–16, 21, 23, 26, 29, 139
 Fermi level of redox systems 60, 347
 – in the excited state 347
 – in the ground state 347
 Fermi level pinning 29, 34, 209, 404
 Fermi's Golden Rule 149
 FeS₂ 115, 312
 fill factor 384
 flash photolysis 82
 flatband potential 112, 116, 212, 401
 fluorescence 343
 fluorescence lifetime 331
 fluorescence quenching 366
 formation of dye dimmers and polymers 354
 Franck–Condon principle 128
 free carrier absorption 11, 372
 free energy and driving source in DSCs 389
- g**
- GaAs 30, 34, 112, 113, 118, 119, 185, 200, 202, 203, 207, 208, 215, 216, 222, 227, 228, 256, 279, 283, 329, 424, 431
 GaInP₂ 202, 216
 GaP 115, 244, 279, 350
 Ge 102, 104, 112, 267–269
 generation current 196
 Gerischer model 138, 140, 347

- Gibbs energy 128
Gouy layer 91, 93, 98
- h**
H₂ formation 185, 404
half-wave potential 181
harmonic oscillator type of fluctuation of the solvent molecules 144
heavy hole 6
Helmholtz capacity 72
Helmholtz layer 63, 90–92, 106
– inner plane 90, 91
– outer plane 91
Heyrovsky–Ilkovic plot 181, 204
HgSe 321
HMO (highest occupied molecular orbital) 345
hole density 14, 15
hot carrier collection 334
hot carrier process 258, 260
hot carrier relaxation 331, 334
hot carrier transfer 327
hot electron 377
hot phonon 329
hydrated electron 314
hydration energy 52
- i**
ideality factor 40
impact ionization 334, 339, 395
impedance measurement 72, 205
impedance spectrum 76, 78, 202, 233
incident photon-to-current efficiency (IPCE) 340, 391
indirect bandgap material 249
indirect bandgap transition 211
infrared measurement 277
infrared spectroscopy (IR) 83
– attenuated total reflection (ATR) 84
inner sphere interaction 52
InP 30, 164, 167, 200, 260, 263, 279, 280, 300, 301
in-situ STM 85, 123
intensity modulated photocurrent spectroscopy (IMPS) 78, 233, 274
internal quantum efficiency (IQE) 396
intrinsic semiconductor 14
inverted region 222
ionization energy 23
irreversible reaction 177, 183
- k**
kinetically controlled current 197
- l**
Langmuir isotherm 202
Langmuir–Blodgett technique 358, 359
laser excitation 310
lattice parameter 440
Levich–Dogonatzte treatment 149
lifetime of the minority carriers 195
light emission 41
light harvesting efficiency (LHE) 342
light hole, small effective mass 6
light-induced process 194
light-induced sterilization 429
low energy electron diffraction (LEED) 85
- m**
majority carrier transfer 198, 200
majority carrier transfer processes at semiconductor–metal junctions 31
Marcus theory 127, 128, 208, 222
maximum power output 382
mechanism for the dissolution of n- and p-silicon 271–278
membrane-based charge separation 419
mercaptopropionic acid (MPA) 340
metal deposition 123, 434, 435
metal surface 23
metal–liquid interface 169
metal–semiconductor contact 26
metalorganic chemical vapor deposition (MOCVD) 296
metal-to-ligand charge transfer (MLCT) 388
microwave application 110
minority carrier injection 70, 71, 217, 255
minority carrier transfer
– p–n junction 38
– processes at semiconductor–metal junctions 35
mobility
– of electrons 17, 441
– of holes 17, 441
– of ions 49, 51
molecular beam epitaxy (MBE) 296
molecular dynamics (MD) simulation 163
molecular orbital model 299
momentum of electrons 8
momentum of photons 8
monograin membrane 312, 409
monomolecular dye layers 359, 360
MoSe₂ 208, 279
Mott–Schottky plot 99, 200, 212
multiple exciton collection 340

- multiple exciton generation (MEG) 336, 395, 420
- multiple quantum well 303
- n*
- N3 371, 388
- N719 388
- nanocrystal (NC) 295
- nanocrystalline film 305, 332
- nanocrystalline TiO₂ 333, 370
- Nernst equation 63
- new approaches and strategies for the development of photoelectrolysis cells 414
- non-adiabatic reaction 134, 146, 149, 167
- nonradiative recombination 343
- o*
- O₂ formation 403
- ohmic contact 41
- one-step redox reaction 186
- open circuit condition 43
- outer sphere interaction 52
- oxidation of ethanol at particle 324
- p*
- p–n junctions 381
- particle 306
- particle size effect on reaction routes 322
- PbS 325, 336, 340, 395
- PbSe 321, 335, 395
- perfect surface 104
- phonon bottleneck 335
- phonon emission 334
- phosphorescence 344
- photocatalyst 415, 419, 427, 428
- photocatalytic reaction 426
- photochemical diode 407–409
- photocleavage of H₂O 404–406
 - energetic requirements 404
 - in the presence of catalysts 404
 - under external bias 405
- photocurrent density 42, 195
- photocurrent excitation spectrum 212
- photocurrent measurement 67
- photocurrent onset 213, 292
- photocurrent relaxation 214
- photodegradation of pollutants 427
- photoelectrochemical photovoltaic cell 400
- photoelectrolysis 402
- photoelectrolysis of H₂O 403
 - by photovoltaics 409
 - conversion efficiency 410
 - tandem cell device 410
- photoelectron emission 313
- photogalvanic effect 376
- photo-Kolbe reaction 317
- photoluminescence 249, 250, 253
- photoluminescence lifetime 216
- photon energy 8–10
- photoreduction of CO₂ 424
- photovoltage 42, 382, 401
- Poisson equation 94
- polyurathane membrane 419
- porous semiconductor surface 293
- porous Si 333
- porous TiO₂ 326, 333
- potential across the space charge layer 26, 96
- potential distribution 91, 92, 102
 - dependence on prepolarization 105
 - pH-dependence 105
- potentiostatic measuring system 67
- power conversion efficiency 422, 423
- processes at quantum wells (MQW, SQW) 329
- q*
- quality factor 381
- quantum dot 296
- quantum efficiency 211
- quantum mechanical treatments of electron transfer processes 145
 - analysis of a two-level system 146
- quantum size effect 295
- quantum well electrode 327, 329, 330
 - multiple quantum well 327
 - single quantum well 327
- quantum yield 233
- quantum yield (QY) 422
- quasi-Fermi level 22, 35, 237
- quasi-Fermi level concept 225, 228
- quenching of excitation energy 354
- r*
- rate constant 164–166, 199, 201, 203, 208
- recombination current 198, 233
- recombination processes 19, 46, 402
 - in direct bandgap semiconductors 19
 - in indirect bandgap semiconductors 20
 - surface recombination 46, 70, 107
 - via traps 20
 - within the space charge region 40
- redox chemistry in quantized colloids 318
- redox potentials of excited molecules 346
- reduction of S₂O₈²⁻ 246
- reduction of H₂O₂ 244
- reduction of protons 206

- reduction of quinones 246
- reduction of semiconductor/liquid junctions 286
- reference electrode 59, 60, 62, 66
 - hydrogen electrode (NHE) 66
 - saturated calomel electrode (SCE) 66
 - silver/silver chloride electrode (Ag/AgCl) 66
- reference potential 59, 60
- reflection coefficient 8
- reflection measurement 110
- reorganization energy 129, 132, 134, 136, 175
 - inner sphere reorganization 132
 - outer sphere reorganization 132, 176
- reorganization of the solvent molecules 53
- resistivity of solids 18
- reversible reaction 182, 183
- Richardson constant 33
- Ross model 400, 412
- rotating ring disc electrode (RRDE) 68
- $\text{Ru}(\text{bipy})_3^{2+/3+}$ 347–349
 - excitation energy 347
 - standard potentials 347
- RuS_2 120, 122, 404
- s**
- sandwich formation between particles 324
- saturation current 196
- scanning electrochemical microscopy (SECM) 69
- scanning tunneling microscopy (STM) 70, 86
- Schottky junction 381
- selective metal deposition 433
- semiconductor particle 295
- semiconductor sensitized cells (SSCs) 394–397
- semiconductor surface 23, 24
- sensitization
 - at metal electrodes 375
 - at semiconductor surfaces modified by a dye 357
 - kinetics of electron transfer 366
 - potential dependence 356
 - processes at nanocrystalline layers 370
 - quantum efficiencies 364
 - singlet mechanism 355
 - supersensitization 364
 - triplet mechanism 355
 - via adsorbed dye molecules 352
- sensitized cell (DSC) 386
- Shockley and Queisser 394
- Shockley–Read recombination 220
- Shockley–Queisser derivation 414
- Shockley–Queisser model 398
- short circuit condition 43
- short circuit current 70, 107
- Si 109, 200, 239, 264, 271, 281, 300, 431
- SiC 279, 349, 377
- single quantum well 330
- SnO_2 241, 242, 349, 350
- SnS_2 350, 353, 365, 366
- solar conversion efficiency 375
- solar energy conversion efficiency 398
- solvated electron 316
- solvation of ions 52
- space charge capacity 72, 109
 - for an intrinsic semiconductor 99
 - Mott–Schottky plot 99
 - Mott–Schottky relation 97
 - of intrinsic semiconductors 97
- space charge layer 26, 34, 63, 91
 - accumulation region 27, 97, 98
 - depletion layer 27, 97, 98
 - inversion region 97, 98
- spectrum of sensitized photocurrents 349, 350
- splitting of atomic and molecular energy states 319
- SrTiO_3 404
- stability factor 288, 290
- stabilization 383
- standard hydrogen electrode 59
- Stark effect 319
- strategies for selecting new stable semiconductors 415
- strategies of electrolysis cell 414
- structure of interfaces 89
 - adsorption 90
 - hydroxylated surfaces 90
- substrate electrode (SE) 391
- superhydrophilicity 430
- superlattice 303
- surface catalyst 424
- surface conductivity 81, 100, 103, 109
- surface dipole 31, 63
- surface modification technique 358, 361
- surface recombination 212, 214, 252, 254
- surface spectroscopic analysis (XPS) 122
- surface state 24, 26, 46, 104, 108
- surface state capacity 101
- synchrotron radiation photoelectron spectroscopy (SRPES) 417

t

Tafel equation 174, 175
 TaON 414, 415
 thermionic emission model 208
 thickness of the diffusion layer 180
 thickness of the space charge layer 99
 third generation of solar cells XI, 395
 time resolved photoluminescence (TRPL) 328
 TiO₂ 308, 316, 324, 350, 361, 372, 429, 434
 TiO₂/CdS sandwich 324
 TiO₂/PbS sandwich 327
 transient absorption in TiO₂ colloids 311
 transmission coefficient 8, 128
 transmission electron microscopy (TEM) 300
 transmission factor 155
 – Landau–Zener transmission coefficient 156
 triexciton 340
 two-electrode configurations in
 photoelectrolysis cells 402
 two-step redox process 244, 246

u

unit cell 1, 2
 unpinning of energy bands by illumination 118, 120
 UV photoelectron spectroscopy (UPS) 85

v

valence band 6, 12
 voltametry 65

w

Warburg impedance 75
 water splitting 414
 wave vector 3–5
 work function 23, 30, 63
 WSe₂ 69, 112, 208, 212, 282, 292

x

X-ray photoelectron spectroscopy (XPS) 85

z

ZnO 222, 248, 319, 321, 324, 350, 364

