

# Contents

<b>1</b>	<b>Photocarrier Recombination Dynamics in Perovskite Semiconductor SrTiO<sub>3</sub></b> . . . . .	<b>1</b>
	Yasuhiro Yamada and Yoshihiko Kanemitsu	
1.1	Introduction . . . . .	1
1.2	Photoluminescence Spectra . . . . .	4
1.3	Band-to-Band Luminescence and Optical Absorption Spectra . . . . .	6
1.4	Photocarrier Recombination Dynamics: Importance of Nonradiative Auger Recombination. . . . .	11
	1.4.1 Undoped Crystals . . . . .	12
	1.4.2 Electron-Doped Crystals . . . . .	16
	1.4.3 Temperature Dependence . . . . .	18
1.5	Surface Oxygen Deficient Layer: Bulk Crystals and Nanoparticles . . . . .	21
1.6	Other Perovskite Semiconductors . . . . .	28
1.7	Summary . . . . .	32
	References . . . . .	33
<b>2</b>	<b>Nano Architectures in Silicon Photovoltaics</b> . . . . .	<b>37</b>
	Nazir P. Kherani	
2.1	Introduction . . . . .	37
2.2	Photovoltaics and Photonic Architectures: A Historical Perspective. . . . .	40
	2.2.1 Photovoltaics . . . . .	40
2.3	Nano Architectures in Silicon Photovoltaics: Recent Advances . . . . .	47
	2.3.1 Introduction . . . . .	47
2.4	Future Outlook . . . . .	58
	References . . . . .	58
<b>3</b>	<b>Electronic Structures of Planar and Nonplanar Polyfluorene</b> . . . .	<b>63</b>
	Takashi Kobayashi, Takashi Nagase and Hiroyoshi Naito	
3.1	Introduction . . . . .	63
3.2	Fundamental Optical Properties . . . . .	65

3.2.1	Conformation of F8 . . . . .	65
3.2.2	Effective Conjugation Length Model . . . . .	67
3.2.3	Photoluminescence (PL) Properties . . . . .	67
3.3	Electronic Structure . . . . .	69
3.3.1	Electroabsorption(EA) Measurements . . . . .	69
3.3.2	Essential-State Model . . . . .	70
3.3.3	EA Spectrum of Glassy F8 . . . . .	70
3.3.4	Transition from Glassy to $\beta$ -phase . . . . .	72
3.3.5	Oscillatory Feature in Crystalline Thin Films. . . . .	75
3.3.6	Discussions . . . . .	76
3.4	Conclusions . . . . .	78
	References . . . . .	79
<b>4</b>	<b>Organic and Excitonic Solar Cells. . . . .</b>	<b>81</b>
	Furong Zhu	
4.1	Introduction . . . . .	81
4.2	Basics of Organic Solar Cells. . . . .	83
4.3	Electrode Modification and Interfacial Engineering. . . . .	88
4.3.1	Plasma-Polymerized Fluorocarbon-Modified Ag Nanoparticles . . . . .	89
4.3.2	Effect of ITO Surface Electronic Properties on OSC Performance . . . . .	90
4.3.3	Ag Nanoparticles-Modified ITO/Plastic Substrate for Flexible OSCs. . . . .	96
4.4	Charge Transport Properties in Bulk-Heterojunction OSCs . . . . .	99
4.4.1	Charge Transport Properties in Polymer/Oxide Composites . . . . .	99
4.4.2	Effect of Oxygen-Induced Traps on Charge Mobility and OSC Performance . . . . .	105
4.5	Absorption Enhancement in OSCs . . . . .	111
4.6	Stability of Bulk-Heterojunction OSCs . . . . .	115
4.7	Conclusions . . . . .	122
	References . . . . .	122
<b>5</b>	<b>Exciton-Plasmon Coupling in Nanocomposites. . . . .</b>	<b>127</b>
	Mahi R. Singh	
5.1	Introduction . . . . .	127
5.2	Surface Plasmon Polaritons . . . . .	129
5.2.1	Quasi-Static Approximation . . . . .	129
5.2.2	Metallic Heterostructures. . . . .	130
5.2.3	Metallic Nanoparticles . . . . .	132
5.3	MNP Polarization . . . . .	135
5.4	Electric Field Enhancement . . . . .	137

5.5	Exciton-Plasmon Interaction. . . . .	139
5.5.1	Dipole–Dipole Interaction . . . . .	140
5.5.2	Interaction Hamiltonian. . . . .	142
5.6	Density Matrix Method . . . . .	144
5.6.1	Two-Level Quantum Dot. . . . .	145
5.6.2	Decay Rate . . . . .	146
5.6.3	Three-Level Quantum Dot. . . . .	148
5.7	Energy Exchange Rate . . . . .	150
5.7.1	Spherical Nanoparticles. . . . .	151
5.8	Quantum Dot-Graphene Hybrid . . . . .	152
5.9	Conclusion. . . . .	154
	References . . . . .	154
<b>6</b>	<b>Influence of Excitonic Processes in the Energy Resolution of Scintillators . . . . .</b>	<b>157</b>
	Jai Singh and Alex Koblov	
6.1	Introduction . . . . .	157
6.1.1	Non-proportionality in Scintillator Light Yield ( $Y$ ). . . . .	159
6.2	Theory of Non-proportional Light Yield . . . . .	160
6.2.1	Rate Equations. . . . .	161
6.2.2	Local Light Yield ( $Y_L$ ) . . . . .	163
6.2.3	Total ScintillatorYield ( $Y$ ). . . . .	166
6.3	Proportional Scintillator Yield . . . . .	171
6.3.1	Excitonic Scintillators ( $f_x = 1$ ). . . . .	171
6.3.2	Non-excitonic Scintillators ( $f_x = 0$ ). . . . .	172
6.3.3	Dependence of Yield on Linear Rates ( $R_1, K_1$ ) . . . . .	173
6.3.4	Dependence of Yield on Bimolecular Quenching Rates ( $K_{2x}, K_{2eh}$ ) . . . . .	176
6.3.5	Dependence of Yield on Auger Quenching Rates ( $K_{3x}, K_{3eh}$ ). . . . .	179
6.3.6	Dependence of Yield on Track Radius $r$ . . . . .	180
6.4	Discussions on Nonproportionality (NPR) in the Yield . . . . .	183
6.4.1	Influence of $R_{1x}$ on NPR. . . . .	183
6.4.2	Influence of Ratio of Concentrations $f_x$ . . . . .	184
6.4.3	Influence of Bimolecular Quenching. . . . .	184
6.4.4	Influence of Auger Quenching . . . . .	185
6.4.5	Influence of Track Radius . . . . .	185
6.4.6	Influence of Evolution of Excitonic Concentration Within the Electron Track . . . . .	187
6.5	Achieving Optimal Proportionality in a Scintillator. . . . .	190
6.6	Conclusions . . . . .	191
	References . . . . .	191

<b>7</b>	<b>Electronic Properties of Noncrystalline Semiconductors</b> . . . . .	193
	Jai Singh	
7.1	Introduction . . . . .	193
7.2	Effective Mass of Charge Carriers in Inorganic Amorphous Semiconductors . . . . .	198
7.2.1	Effective Mass of Electrons in the Conduction Band . . . . .	198
7.2.2	Effective Mass of Holes in the Valence Band . . . . .	202
7.3	Anomalous Hall Effect . . . . .	203
7.4	Excitonic States in Noncrystalline Solids . . . . .	206
7.4.1	Possibility (1): Creation of an Exciton by Exciting Both Electron and Hole in Extended States . . . . .	209
7.4.2	Possibilities (2) and (3): Electron Excited in Extended and Hole in Tail, and Electron Excited in Tail and Hole in Extended States . . . . .	210
7.4.3	Possibility (4): Both the Electron and Hole Are Excited in Their Respective Tail States . . . . .	210
7.5	Excitonic Photoluminescence and Phosphorescence . . . . .	211
7.5.1	Emission from Singlet Excitons (Photoluminescence) . . . . .	211
7.5.2	Emission from Triplet Excitons (Phosphorescence) . . . . .	213
7.6	Conclusions . . . . .	226
	References . . . . .	226
<b>8</b>	<b>Excitonic Processes in Organic Semiconductors and Their Applications in Organic Photovoltaic and Light Emitting Devices</b> . . . . .	229
	Monishka Rita Narayan and Jai Singh	
8.1	Introduction . . . . .	230
8.2	Organic Solar Cells . . . . .	230
8.2.1	Photon Absorption and Formation of Singlet Triplet Excitons in OSCs . . . . .	232
8.2.2	Exciton Diffusion in Bulk-Heterojunction Organic Solar Cells . . . . .	237
8.2.3	Diffusion Coefficient and Excitonic Diffusion Length . . . . .	238
8.2.4	Exciton Dissociation in Bulk-Heterojunction Organic Solar Cells . . . . .	240
8.3	Organic Light Emitting Devices . . . . .	246
8.4	Conclusions . . . . .	249
	References . . . . .	250

**9 Optical and Electronic Processes in Semiconductor Materials for Device Applications . . . . . 253**  
 Igor P. Marko and Stephen J. Sweeney

9.1 Introduction: Optical and Electronic Processes in Semiconductor Optoelectronic Devices . . . . . 253

9.1.1 Carrier Injection and Recombination. . . . . 254

9.1.2 Spontaneous Emission Analysis . . . . . 257

9.1.3 High Pressure Analysis . . . . . 259

9.2 Near-Infrared Quantum Well Lasers . . . . . 263

9.2.1 The Temperature Dependence of 1.3- and 1.5- $\mu\text{m}$  InGaAs(P)/InP Multi-quantum Well Semiconductor Lasers . . . . . 264

9.2.2 Near-Infrared InGaAlAs/InP Based Lasers. . . . . 269

9.2.3 Analysis of Near-Infrared “Dilute Nitride” InGaAsN/GaAs Lasers . . . . . 271

9.3 New Approaches in Development of the Near-Infrared Lasers . . . . . 274

9.3.1 InAs-Based Quantum Dots. . . . . 274

9.3.2 Bismuth Containing III–V Material Systems . . . . . 277

9.4 Semiconductor Emitters for Mid-Infrared Applications . . . . . 280

9.4.1 Interband Structures for Longer Wavelength Lasers and LEDs . . . . . 280

9.4.2 Short-Wavelength Quantum Cascade Lasers . . . . . 283

9.4.3 Inter-Band Type II “W”-Cascade Lasers. . . . . 286

9.5 Physical Properties of Devices Emitting in Visible Range of the Spectrum . . . . . 287

9.5.1 AlGaInP Lasers . . . . . 287

9.5.2 Efficiency Droop Problem in InGaN Light Emitting Devices . . . . . 289

9.6 Conclusions . . . . . 293

References . . . . . 293

**10 Scintillation Detectors of Radiation: Excitations at High Densities and Strong Gradients. . . . . 299**  
 R. T. Williams, J. Q. Grim, Qi Li, K. B. Ucer, G. A. Bizarri and A. Burger

10.1 Introduction . . . . . 300

10.2 Measurements of Light Yield Functions . . . . . 304

10.2.1 Gamma Photopeak Resolution . . . . . 305

10.2.2 Gamma Energy Response . . . . . 306

10.2.3 Electron Energy Response . . . . . 306

10.2.4 X-ray Photon Energy Response . . . . . 308

10.2.5 Ultraviolet Photon Density Response . . . . . 309

10.3	Measuring Photon Density Response by the “Interband z Scan” Technique . . . . .	310
10.3.1	Experiment . . . . .	311
10.3.2	Pure 2nd Order Quenching in BGO Versus 3rd Order $\text{SrI}_2$ . . . . .	312
10.3.3	Mixed Kinetic Orders in CsI:Tl and NaI:Tl; Measuring the Free-Carrier Fraction $\eta_{eh}$ . . . . .	314
10.3.4	Experimental Determination of the Radius of the NLQ Zone at Track End in NaI:Tl and $\text{SrI}_2$ . . . . .	318
10.4	Analysis of Photon Density Response . . . . .	319
10.4.1	Second Order Quenching. . . . .	319
10.4.2	Third Order Quenching . . . . .	321
10.5	Wings, Humps, Charge Separation, and Energy Storage . . . .	329
10.6	Tabulation of Results from Photon Density Response . . . . .	332
10.7	Calculating Local Light Yield Versus Excitation Density in Electron Tracks . . . . .	335
10.7.1	Dilution of e-h Density in the Track Core by Ambipolar Diffusion . . . . .	336
10.7.2	Effects of Charge Separation . . . . .	340
10.7.3	Recombination in the Field of a Cylinder of Self-Trapped Holes. . . . .	341
10.7.4	Effect of Charge Separation During Thermalized Diffusion on Light Yield. . . . .	344
10.7.5	Effect on Light Yield of Charge Separation Due to Hot Electron Diffusion. . . . .	346
10.8	Calculating Electron Energy Response . . . . .	347
10.9	Toward a Design Rule: General Trends in Scintillator Proportionality and Light Yield Versus a Few Material Parameters . . . . .	352
	References . . . . .	356



<http://www.springer.com/978-981-287-130-5>

Excitonic and Photonic Processes in Materials

Singh, J.; Williams, R.T. (Eds.)

2015, XVI, 358 p. 184 illus., 113 illus. in color.,

Hardcover

ISBN: 978-981-287-130-5