

Contents

Preface *xi*

1	Portable and Wearable Sensing Technologies for Biochemical Detection	1
	<i>Xin Li, Fenni Zhang, and Qingjun Liu</i>	
1.1	Biochemical Detection: Increasing Demands and Challenges	1
1.2	Portable Sensing Technologies: Efficient Biochemical Analysis	2
1.3	From Portable to Wearable: Toward In Situ Biosensing	4
1.3.1	Timeline of Major Development in Biosensors	4
1.3.2	Building Blocks and Applications of Wearable Sensing Systems	7
1.4	Summary and Outlook	12
	Acknowledgments	14
	References	14
2	Portable Electrochemical Sensing Systems	19
	<i>Zijian An, Yue Wu, Yuting Zhao, Yanli Lu, and Qingjun Liu</i>	
2.1	Fundamentals of Portable Electrochemical Sensing Systems	20
2.1.1	A Brief Instruction of Electrochemistry	20
2.1.2	Measurement of Potential and Current	22
2.1.3	Electrode System	23
2.1.4	Principle of Potentiostat	24
2.2	Techniques of Portable Electrochemical Measurement	25
2.2.1	Open-Circuit Potential Method	25
2.2.2	Amperometric Method	25
2.2.3	Cyclic Voltammetry	26
2.2.4	Electrochemical Impedance Spectroscopy	28
2.3	Fabrication of Portable Electrochemical Systems	28
2.3.1	Portable Electrochemical Electrode	29
2.3.2	Electrode Modification and Functionalization	30
2.3.3	Portable Electrochemical Measuring Systems	31
2.4	Applications of Portable Electrochemical Sensing Systems	31
2.4.1	Direct Electrochemical Detection	32
2.4.2	Catalytic Electrochemical Detection	32

2.4.3	Indirect Catalytic Electrochemical Detection	34
2.5	Summary and Outlook	35
	Acknowledgments	36
	References	36
3	Portable Optical Sensing Systems	41
	<i>Jinbiao Ma, Jiahao Xu, Baiqi Cui, Dehong Yang, Ying Fang, Xiaoyin Liu, and Fenni Zhang</i>	
3.1	Fundamentals of Portable Optical Sensing Systems	41
3.2	Plasmonic Sensing-Based Portable Optical Systems	42
3.2.1	Technique Principle	43
3.2.2	Fabrication and Applications	46
3.3	Scattering Sensing-Based Portable Optical Systems	49
3.3.1	Technique Principle	50
3.3.2	Fabrication and Applications	51
3.4	Chemiluminescence Sensing-Based Portable Optical Systems	54
3.4.1	Technique Principle	55
3.4.2	Fabrication and Applications	55
3.5	Colorimetric Sensing-Based Portable Optical Systems	57
3.5.1	Technique Principle	58
3.5.2	Fabrication and Applications	58
3.6	Summary and Outlook	62
	Acknowledgments	62
	References	62
4	Portable Optical–Electrochemical-Coupled Sensing Systems	71
	<i>Zetao Chen, Fenni Zhang, Yanli Lu, and Qingjun Liu</i>	
4.1	Fundamentals of Optical–Electrochemical-Coupled Sensing Systems	72
4.2	Optical–Electrochemical-Coupled Sensing Techniques	73
4.2.1	Electrophoresis-Enhanced Localized Surface Plasmon Resonance	73
4.2.2	Potential-Coupled Localized Surface Plasmon Resonance	75
4.2.3	Bioelectronic Modulation of Localized Surface Plasmon Resonance	76
4.3	Fabrication of Optical–Electrochemical-Coupled Electrodes	77
4.3.1	Nanohole Array	78
4.3.2	Nanocone Array	79
4.3.3	Nanoparticles-Coupled ITO Electrode	80
4.4	Construction of Portable Optical–Electrochemical-Coupled Systems	81
4.4.1	Construction of Optical–Electrochemical-Coupled System	81
4.4.2	Construction of Electrochemical Single-Wavelength LSPR System	83
4.5	Summary and Outlook	85
	Acknowledgments	85
	References	86

5	Smartphone-Based Portable Sensing Systems for Point-of-Care Detections	89
	<i>Guang Liu, Yue Wu, Yutian Wang, Weihong Ye, Minyang Wu, and Qingjun Liu</i>	
5.1	Smartphone-Based Optical Sensing System	90
5.1.1	Spectroscopy Sensing	90
5.1.2	Electrochemical Local Surface Plasmon Resonance (LSPR) Sensing	91
5.1.3	Electrochemiluminescence (ECL) Sensing	93
5.2	Smartphone-Based Electrochemical System	94
5.2.1	Amperometry Sensing	95
5.2.2	Potentiometry Sensing	97
5.2.3	Impedimetric Sensing	97
5.3	Smartphone-Based Photoelectrochemical (PEC) System	99
5.4	Smartphone-Based Point-of-Care Detections	101
5.5	Summary and Outlook	103
	Acknowledgments	104
	References	104
6	Flexible Electronics for Wearable Sensing Systems	111
	<i>Qi-Qi Fu</i>	
6.1	Flexible Electronics: Definition and Development	112
6.2	Advantages of Flexible Electronics in Wearable Sensing	112
6.3	Fabricating Wearable Sensing Systems with Flexible Electronic Technologies	113
6.3.1	Design Strategies	114
6.3.2	Fabrication Technologies	118
6.3.3	Assembling Technologies	122
6.4	Wearable Sensing Systems Fabricated by Using Flexible Electronic Technologies	125
6.4.1	Wearable Neonatal Intensive Care System	127
6.4.2	Wearable Ultrasonic Sensing Systems	127
6.5	Summary and Outlook	129
	Acknowledgment	131
	References	131
7	Wearable Sensors for <i>In Situ</i> Biofluid Analysis	139
	<i>Zhengan Shi, Chaobo Dai, Feiyue Fang, Yifan Shuai, Chuhan Xiong, and Qingjun Liu</i>	
7.1	Wearable Sensors for Sweat Analysis	140
7.1.1	Wearable Sweat Sensors for Health Monitoring	141
7.1.2	Wearable Sweat Sensors for Disease Diagnosis	142
7.1.3	Wearable Sweat Sensors for Nutrition Management	145
7.2	Wearable Sensors for Saliva Analysis	145
7.2.1	Wearable Saliva Sensors for Food Intake Analysis	145
7.2.2	Wearable Saliva Sensors for Salivary Metabolite Monitoring	147
7.2.3	Wearable Saliva Sensors for Oral Disease Detection	147

7.3	Wearable Sensors for Interstitial Fluid (ISF) Analysis	149
7.4	Wearable Sensors for Tear Analysis	151
7.5	Summary and Outlook	152
	Acknowledgments	153
	References	153
8	Wearable Sensors for <i>In Situ</i> Breath Analysis	157
	<i>Jingjiang Lv, Xin Li, Jingying Pan, Rujing Sun, Yanli Lu, and Qingjun Liu</i>	
8.1	Wearable Breath Sensors for Physiological Monitoring	157
8.1.1	Humidity-Based	158
8.1.2	Temperature-Based	160
8.1.3	Pressure-Based	162
8.2	Wearable Breath Sensors for Volatile Markers Analysis	162
8.2.1	Ethanol	163
8.2.2	Acetone	165
8.2.3	Other Breath Markers	168
8.3	Wearable Breath Sensors for Virus Detection	170
8.3.1	Electrochemical-Based	170
8.3.2	Synthetic Biology-Based	172
8.4	Summary and Outlook	174
	Acknowledgments	174
	References	175
9	Wearable Sensors for Wound Diagnosis and Close-Loop Therapeutics	179
	<i>Lihua Peng, Jinyu Zhao, and Minhong Tan</i>	
9.1	Wearable Sensors for Wound Monitoring	180
9.1.1	Characteristic Parameters of WSS for Wound Healing	180
9.1.2	Different Detecting Methods of WSS for Wound Healing	182
9.1.3	Representative WSS for Wound Healing	183
9.2	Wearable Drug Delivery for Wound Treatment	186
9.2.1	Microscale WDDS	188
9.2.2	Hydrogel-Based WDDS	189
9.2.3	Textile-Based WDDS	190
9.3	Integrating Wearable Sensors with Wearable Therapy	190
9.3.1	Thermally Responsive IIS for Wound Treatment	192
9.3.2	Mechanically Responsive IIS for Wound Treatment	194
9.3.3	Electrically Responsive IIS for Wound Treatment	195
9.4	Close-Loop Therapeutics with Wearable Devices	197
9.4.1	Energy Supply for Closed-Loop System	199
9.4.2	The Integration of Closed-Loop System	199
9.5	Summary and Outlook	200
	Acknowledgments	203
	References	203

10	Self-Powered Sensors for Wearable Detections	207
	<i>Yang Zou and Zhou Li</i>	
10.1	Biofuel-Based Sensors	208
10.1.1	Working Principles	208
10.1.2	Materials and Fabrication	209
10.1.3	Applications for Wearable Detections	210
10.2	Thermoelectric Nanogenerator-Based Sensors	212
10.2.1	Working Principles	212
10.2.2	Materials and Fabrication	212
10.2.3	Applications for Wearable Detections	214
10.3	Triboelectric Nanogenerator-Based Sensors	215
10.3.1	Working Principles	215
10.3.2	Materials and Fabrication	217
10.3.3	Applications for Wearable Detections	217
10.4	Piezoelectric Nanogenerator-Based Sensors	220
10.4.1	Working Principle	220
10.4.2	Materials and Fabrication	220
10.4.3	Applications for Wearable Detections	222
10.5	Summary and Outlook	224
	Acknowledgments	226
	References	226
	Index	233