

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 *In Situ* Breath Analysis 157**
Jingjiang Lv, Xin Li, Jingying Pan, Rujing Sun, Yanli Lu, and Qingjun Liu
- 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**
Lihua Peng, Jinyu Zhao, and Minhong Tan
- 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 |

