

TABLE OF CONTENTS

Chapter 1. Introduction	1
1.1 Brief Historical Background	2
1.2 Early Applications for Noble Metal Electrodes	4
1.3 Early Optical Methods	5
1.4 Ideal Biosensor Characteristics	6
1.5 Ideal Measurement Systems	16
1.6 References	18
Chapter 2. Basic Electrochemical Principles	21
2.1 Electrochemical Cells	21
2.2 Oxidation-Reduction Reactions	24
2.3 Voltage and Current at Standard Conditions	25
2.4 Steady State Voltammogram	27
2.5 Transient Responses	29
2.6 Potentiostatic Response	30
2.7 Asymptotic Solutions and Data Transformations	31
2.8 Galvanostatic Response	34
2.9 Coulostatic Response	37
2.10 References	37
Chapter 3. Electrochemical Transducers in Biology and Medicine	39
3.1 Glass pH Electrodes	39
3.2 Metal Oxide pH Electrodes	41
3.3 pH-Sensitive Membranes	43
3.4 Oxygen Electrodes	43
3.5 Carbon Dioxide Electrodes	48

3.6	Hydrogen Gas Electrodes	49
3.7	Hydrogen Peroxide Electrodes	50
3.8	Carbon Surface Electrodes	52
3.9	Ion-Sensitive Electrodes	53
3.10	Other Electrochemical Detection Methods	54
3.11	Clinical Applications of Electrochemical Transducers	57
3.12	References	59

Chapter 4. Enzyme-Based Electrochemical Biosensors 63

4.1	Enzyme Biocatalysis Theory	63
4.2	Immobilization Techniques	68
4.3	Glucose Biosensor	71
4.4	Blood Glucose Monitoring	73
4.5	Industrial Glucose Monitoring	76
4.6	Urea Biosensor	76
4.7	Alcohol Biosensors	77
4.8	More Single Enzyme Biosensors	79
4.9	Multiple Enzyme Biosensors	81
4.10	Carbon Electrode Enzyme-Based Biosensors	85
4.11	Organic Phase Enzyme Biosensors	87
4.12	Alternate Electron Donors	88
4.13	References	91

Chapter 5. Fabrication and Miniaturization Techniques 95

5.1	Microelectrodes	95
5.2	Enzyme Modified Microelectrodes	109
5.3	Miniaturized Arrays	112
5.4	Semiconductor Needle	116
5.5	ENFET Biosensors	118
5.6	Encapsulation and Membranes	119
5.7	References	120

Chapter 6. Optical Technology 125

6.1	Principles of Optical Measurements	125
6.2	Absorption Spectroscopy	126
6.3	Reflectance Spectroscopy	128
6.4	Chemiluminescence	129
6.5	Fluorescence	131
6.6	Phosphorescence	133
6.7	Oxyhemoglobin and Oximetry	137
6.8	Digital Image Processing	142
6.9	Optodes	142

6.10	Optical Waveguides	146
6.11	Light-Addressable Potentiometric Sensor	148
6.12	References	148
Chapter 7.	Miscellaneous Transducer Technologies	151
7.1	Enzyme-Based Calorimetry	151
7.2	Piezoelectric Microbalances	154
7.3	Surface Acoustic Wave Transducers	157
7.4	Chemomechanical Hydrogels	159
7.5	Liquid Crystal Sensors	160
7.6	Enzyme Reactors with High Performance Liquid Chromatography	161
7.7	References	162
Chapter 8.	Immunosensors	163
8.1	Potentiometric Immunosensors	164
8.2	Amperometric Immunosensors	166
8.3	Enzyme-Linked Immunoassays	166
8.4	Piezoelectric Microbalance Immunosensors	168
8.5	Optical Immunosensors	170
8.6	Bioluminescent Immunoassay	171
8.7	Fluorescence Immunoassay	171
8.8	Surface Resonance	174
8.9	Laser Magnet Immunoassay	175
8.10	References	176
Chapter 9.	"Living" Biosensors	179
9.1	Microbial Biosensors	179
9.2	Bioluminescent Bacteria	182
9.3	Yeast-Based Biosensors	183
9.4	Botanical Biosensors	183
9.5	Biosensors Using Cultured Cells	185
9.6	Biosensors Using Intact Tissues	188
9.7	Biosensors Using Receptor Elements	191
9.8	References	192
Chapter 10.	Future Directions	195
10.1	Scanning Electrochemical Microscopy	195
10.2	Nanofabrication	198
10.3	Microdialysis with Electrochemical Detection	200
10.4	Advances in Semiconductor Fabrication Technology	201
10.5	Advances in Optical and Imaging Technology	203

10.6	Advances in Enzyme and Protein Engineering	207
10.7	Projections for Food and Beverage Industries	208
10.8	Projections for Defense Sector	208
10.9	Projections for Environmental Applications	208
10.10	Projections for Medical Instruments Industry	209
10.11	Projections for Biotechnology and Pharmaceutical Industries	209
10.12	References	210
<i>Author Index</i>		213
<i>Subject Index</i>		217
<i>About the Author</i>		221