

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Sensors and Sensor Science	1
1.1.1	Sensors – Eyes and Ears of Machines	1
1.1.2	The Term ‘Sensor’	3
1.2	Chemical Sensors	3
1.2.1	Characteristics of a Chemical Sensor	3
1.2.2	Elements of Chemical Sensors	7
1.2.3	Characterisation of Chemical Sensors	11
1.3	References	13
<b>2</b>	<b>Fundamentals</b>	<b>15</b>
2.1	Sensor Physics	15
2.1.1	Solids	15
2.1.2	Optical Phenomena and Spectroscopy	25
2.1.3	Piezoelectricity and Pyroelectricity	37
2.2	Sensor Chemistry	38
2.2.1	Chemical Equilibrium	38
2.2.2	Kinetics and Catalysis	41
2.2.3	Electrolytic Solutions	42
2.2.4	Acids and Bases, Deposition Processes and Complex Compounds	43
2.2.5	Redox Equilibria	48
2.2.6	Electrochemistry	51
2.2.7	Ion Exchange, Solvent Extraction and Adsorption Equilibria	72
2.2.8	Special Features of Biochemical Reactions	78
2.3	Sensor Technology	82
2.3.1	Thick-Film Technology	83
2.3.2	Thin-Film Technology and Patterning Procedures	85
2.3.3	Surface Modification and Ordered Monolayers	87
2.3.4	Microsystems Technology	96
2.4	Measurement with Sensors	99
2.4.1	Primary Electronics for Sensors	99
2.4.2	Instruments for Electric Measurements	103
2.4.3	Optical Instruments	104
2.5	References	112

<b>3</b>	<b>Semiconductor Structures as Chemical Sensors</b>	115
3.1	References	117
<b>4</b>	<b>Mass-Sensitive Sensors</b>	119
4.1	BAW Sensors	120
4.2	SAW Sensors	121
<b>5</b>	<b>Conductivity Sensors and Capacitive Sensors</b>	123
5.1	Conductometric Sensors	124
5.2	Resistive and Capacitive Gas Sensors	126
5.2.1	Gas Sensors Based on Polycrystalline Semiconductors	126
5.2.2	Gas Sensors Made of Polymers and Gels	129
5.3	Resistive and Capacitive Sensors for Liquids	130
5.4	References	132
<b>6</b>	<b>Thermometric and Calorimetric Sensors</b>	133
6.1	Sensors with Thermistors and Pellistors	133
6.2	Pyroelectric Sensors	135
6.3	Sensors Based on Other Thermal Effects	136
6.4	References	136
<b>7</b>	<b>Electrochemical Sensors</b>	137
7.1	Potentiometric Sensors	138
7.1.1	Selectivity of Potentiometric Sensors	141
7.1.2	Ion-Selective Electrodes	142
7.1.3	The Ion-Selective Field Effect Transistor (ISFET)	159
7.1.4	Measurement with Potentiometric Sensors	162
7.2	Amperometric Sensors	166
7.2.1	Selectivity of Amperometric Sensors	167
7.2.2	Electrode Design and Examples	169
7.2.3	Measurement with Amperometric Sensors	173
7.3	Sensors Based on Other Electrochemical Methods	175
7.4	Electrochemical Biosensors	175
7.4.1	Fundamentals	175
7.4.2	Classes of Electrochemical Biosensors	179
7.5	References	196
<b>8</b>	<b>Optical Sensors</b>	199
8.1	Optical Fibres as a Basis for Optical Sensors	199
8.2	Fibre Sensors Without Chemical Receptors (Mediators)	202
8.3	Optodes: Fibre Sensors with a Chemical Receptor	205
8.3.1	Overview	205
8.3.2	Optodes with Simple Receptor Layers	208
8.3.3	Optodes with Complex Receptor Layers	211

8.4	Sensors with Planar Optical Transducers . . . . .	211
8.4.1	Planar Waveguides . . . . .	211
8.4.2	Surface Plasmon Resonance and Resonant-Mirror Prism Couplers . . . . .	213
8.5	Optical Biosensors . . . . .	215
8.5.1	Fundamentals . . . . .	215
8.5.2	Optical Enzyme Sensors . . . . .	215
8.5.3	Optical Bioaffinity Sensors . . . . .	218
8.5.4	Optical DNA Sensors . . . . .	221
8.6	Sensor Systems with Integrated Optics . . . . .	223
8.7	References . . . . .	225
<b>9</b>	<b>Chemical Sensors as Detectors and Indicators . . . . .</b>	<b>227</b>
9.1	Indicators for Titration Processes . . . . .	227
9.2	Flow-Through Detectors for Continuous Analysers and for Separation Techniques . . . . .	229
9.2.1	Continuous Analysers . . . . .	230
9.2.2	Separation Methods . . . . .	234
9.3	References . . . . .	239
<b>10</b>	<b>Sensor Arrays and Micro Total Analysis Systems . . . . .</b>	<b>241</b>
10.1	Two Trends and Their Causes . . . . .	241
10.2	Smart Sensors and Sensor Arrays . . . . .	242
10.2.1	Intelligence in Sensors . . . . .	242
10.2.2	Sensor Arrays . . . . .	245
10.3	Micro Total Chemical Analysis Systems ( $\mu$ -TASs) . . . . .	253
10.3.1	History . . . . .	253
10.3.2	Technological Aspects . . . . .	258
10.3.3	Characteristic Operations and Processes in Micro Total Analysers . . . . .	259
10.3.4	Examples of $\mu$ -TAS . . . . .	262
10.4	References . . . . .	265
	<b>Subject Index . . . . .</b>	<b>267</b>

<http://www.springer.com/978-3-540-45742-8>

Chemical Sensors

An Introduction for Scientists and Engineers

Gründler, P.

2007, X, 274 p., Hardcover

ISBN: 978-3-540-45742-8