Table of Contents

Preface to the Second Edition V

Foreword VII

Acknowledgements IX

Table of Contents XIII

Abbreviations XVII

1 Introduction 1

2 Solid-State Reactions 5

2.1 Reactions Between Solid Compounds 5
2.1.1 Ceramic Method 5
2.1.2 Carbothermal Reduction 18
2.1.3 Combustion Synthesis 24
2.1.4 Sintering 31
2.2 Solid–Gas Reactions 40
2.3 Decomposition and Dehydration Reactions 43
2.4 Intercalation Reactions 45
2.4.1 General Aspects 45
2.4.2 Preparative Methods 51
2.4.3 Pillaring of Layered Compounds 57
2.5. Further Reading 60

3 Formation of Solids from the Gas Phase 63

3.1 Chemical Vapor Transport 63
3.2 Chemical Vapor Deposition 71
3.2.1 General Aspects 72
3.2.2 Metal CVD 89
3.2.3 Diamond CVD 98
3.2.4 CVD of Metal Oxides 102
3.2.5 CVD of Metal Nitrides 106
3.2.6 CVD of Compound Semiconductors 108
3.3 Aerosol Processes 112

3.4 Further Reading 126

4 Formation of Solids from Solutions and Melts 129

4.1 Glass 129
4.1.1 The Structural Theory of Glass Formation 131
4.1.2 Crystallization versus Glass Formation 135
4.1.3 Glass Melting 141
4.1.4 Metallic Glasses 147
4.2 Precipitation 150
4.3 Biomaterials 158
4.3.1 Biogenic Materials and Biomineralization 159
4.3.2 Synthetic Biomaterials 171
4.3.3 Biomimetic Materials Chemistry 177
4.4 Solvothermal Processes 181
4.4.1 Hydrothermal Synthesis of Single Crystals 181
4.4.2 Hydrothermal Synthesis 189
4.4.3 Hydrothermal Leaching 191
4.5 Sol–Gel Processes 192
4.5.1 The Physics of Sols 196
4.5.2 Sol–Gel Processing of Silicate Materials 200
4.5.3 Sol–Gel Chemistry of Metal Oxides 215
4.5.4 Inorganic–Organic Hybrid Materials 221
4.6 Further Reading 233

5 Preparation and Modification of Inorganic Polymers 235

5.1 General Aspects 235
5.1.1 Polymeric Materials 237
5.1.2 Crosslinking 238
5.1.3 Preceramic Polymers 241
5.2 Polysiloxanes (Silicones) 244
5.2.1 Properties and Applications of Silicones 244
5.2.2 Structure of Silicones 248
5.2.3 Preparation of Silicones 250
5.3 Polyphosphazenes 261
5.3.1 Properties and Applications of Polyphosphazenes 261
5.3.2 Preparation and Modification 264
5.4 Polysilanes 268
5.4.1 Properties and Applications of Polysilanes 268
5.4.2 Preparation and Modification of Polysilanes 274

5.4.3 Crosslinking of Polysilanes 279
5.5 Polycarbosilanes 280
5.5.1 SiC Fibers from Polycarbosilanes (Yajima Process) 280
5.5.2 Chemical Issues of Polymer Preparation, Curing and Pyrolysis 282
5.6 Polysilazanes and Polycarbosilazanes 289
5.6.1 Preparation of Polysilazanes and Polycarbosilazanes 290
5.6.2 Curing and Pyrolysis Reactions 292
5.7 Other Inorganic Polymers 293
5.7.1 Other Phosphorus-Containing Polymers 294
5.7.2 Poly(oxothiazenes) 295
5.7.3 Transition Metal-Containing Polymers 296
5.7.4 Preceramic Polymers for BN 299
5.8 Further Reading 300

6 Porous Materials 305

6.1 Introduction to Porosity 306
6.2 Metallic Foams and Porous Metals 310
6.2.1 Casting Techniques 311
6.2.2 Gas–Eutectic Transformation 314
6.2.3 Powder Metallurgy 315
6.2.4 Metal Deposition 317
6.3 Aerogels 318
6.3.1 Drying Methods 319
6.3.2 Properties and Applications 324
6.4 Porous Solids with an Ordered Porosity 325
6.4.1 Microporous Crystalline Solids 326
6.4.2 Mesoporous Solids with Ordered Porosity 340
6.4.3 Macroporous Solids with Ordered Porosity 347
6.5 Incorporation of Functional Groups into Porous Materials 349
6.6 Further Reading 351

7 Nanostructured Materials 353

7.1 Nanoparticles and Nanocrystalline Materials 355
7.1.1 Nanocrystalline Ceramics 355
7.1.2 Semiconductor Nanoparticles 360
7.1.3 Metal Nanoparticles 365
7.2 Nanotubes 375
7.3 Mono- and Multilayers 379

7.3.1 Multilayers of Inorganic Materials 379
7.3.2 Langmuir Monolayers 380
7.3.3 Self-assembled Monolayers 382
7.4 Further Reading 384

8 Glossary 387

Index 395