Contents

List of Contributors xi
Preface xiii

1 Introduction 1
James Zhijian Shen and Tomaž Kosmač

2 Teeth
Haifeng Chen and Yihong Liu

2.1 Introduction 5
2.2 Microstructure of Teeth 6
2.3 Optical Properties of Teeth 14
2.4 Mechanical Properties of Teeth 18
2.5 Common Defects and Damage 18
Acknowledgments 20
References 20

3 Dental Prostheses
Jing Zhao and Xinzhi Wang

3.1 Introduction of Prosthodontics and Dental Prostheses 23
3.2 Restoration of Tooth Defects 25
3.3 Restoration of Partial Edentulism 36
3.4 Restoration of Complete Edentulism 43
Acknowledgments 48
References 48

4 Dental Implants
Belinda Reinhardt and Thomas Beikler

4.1 Principle Structure of Dental Implants 52
4.2 Implants 60
4.3 Abutments 62
4.4 Suprastructure 65
4.5 Clinical Procedures 66
4.6 Fitting and Bite Force 69
4.7 Infection Management 71
4.8 Osseointegration 72
References 73

5 Clinical Failures of Ceramic Dental Prostheses

Yihong Liu and James Zhijian Shen

5.1 Fractographic Analysis of Ceramics and Glasses 78
5.2 Failures of Ceramic Dental Prostheses 84
Acknowledgment 101
References 101

6 Advanced Ceramics

David Salamon

6.1 Introduction 104
6.2 Hierarchical Structures 108
6.3 Structure–Property Relations 112
6.4 Optical Properties 118
Acknowledgments 121
References 121
Further Reading 122

7 Advanced Ceramic Processes

Martin Trunec and Karel Maca

7.1 Introduction 124
7.2 Powder Treatment 124
7.3 Shape-forming Processes 126
7.4 Drying and Binder Removal 139
7.5 Sintering 142
References 147

8 Microstructure Characterization of Advanced Ceramics

Saso Sturm and Boštjan Jančar

8.1 Surface Topography 151
8.2 Porosity and Pore Structure 158
8.3 Microscopic Defects 160
8.4 Interfacial Bonding Structures 164
References 170

9 Mechanical Properties and Reliability of Advanced Ceramics

Tanja Lube and Robert Danzer

9.1 Introduction 174
9.2 Fracture Mechanics 174
9.3 Sub-critical Crack Growth 183
9.4 Fatigue 187
9.5 Other Reasons for Damage 188

9.6 Mechanical Testing of Advanced Ceramics 189
9.7 Fractography 194
9.8 Concluding Remarks 194
References 195

10 Interfaces Between Tissues and Ceramics
Peter Schüpbach

10.1 Introduction 201
10.2 Methodologies 202
10.3 Interface between Ceramic Implants and Bone 202
10.4 Interface between Porous Ceramic Implants and Bone 208
10.5 Interface between Ceramics and Soft Tissues 212
Conclusions 215
Acknowledgments 215
References 215

11 Alumina- and Zirconia-based Ceramics for Load-bearing Applications
Corrado Piconi, Saverio Giovanni Condo and Tomaž Kosmač

11.1 Introduction 220
11.2 Alumina in Dentistry 220
11.3 Zirconia in Dentistry 227
11.4 Alumina-zirconia Composites in Dentistry 240
11.5 Adhesion 244
References 248

12 Dental Glasses and Glass-ceramics
Simon Jegou Saint-Jean

12.1 Introduction 255
12.2 Classes of Dental Glass-ceramics 257
12.3 Limitations and Challenges 270
12.4 Future Development 274
Conclusion 275
Acknowledgments 275
References 275

13 Requirements of Bioactive Ceramics for Dental Implants and Scaffolds
James Zhijian Shen and Jenny Fäldt

13.1 Introduction 280
13.2 Osseointegration 281
13.3 Phenomenological View of Bioactivity 283
13.4 Biological View of Bioactivity 287

13.5 Load-bearing Dental Implants 291
13.6 Morphogenetically Active Scaffolds for Bone Tissue Engineering 295
Acknowledgments 297
References 297

14 Surface Modifications of Load-bearing Ceramics for Improved Osseointegration
Martin Stefanic and Tomaž Kosmač
14.1 Introduction 301
14.2 Modifications of Surface Topography 303
14.3 Modifications of Surface Chemistry 309
References 320

15 Industrial-scale Production of Customized Ceramic Prostheses
Dag Henrik Bergsjö, Matts Andersson, Rikard Söderberg and Johan Carlson
15.1 Introduction 327
15.2 The History of Customized Production from the Procera Perspective 329
15.3 Ceramic Versus Metallic Materials 331
15.4 CAI/CAD/CAM 332
15.5 Production of Dental Prosthetics 334
15.6 Simulation Tools 338
15.7 Quality Control 340
References 341

16 Advanced Dental-restoration Materials: Concepts for the Future
James Zhijian Shen and Tomaž Kosmač
16.1 Introduction 343
16.2 Strong Glasses and Glass-ceramics 345
16.3 Functional Gradient Materials 347
16.4 Thin and Multilayered Coatings 348
16.5 Translucent Load-bearing Ceramics 351
16.6 Polymer Ceramic Hybrids 353
16.7 Strong Porous Ceramics 354
16.8 Biomimetic Materials 355
Acknowledgments 356
References 357

17 Defect Minimization in Prosthetic Ceramics

Erik Adolfsson and James Zhijian Shen

17.1 Introduction 359
17.2 The Decisive Role of Defects 360
17.3 Minimizing Defects in Powders 361
17.4 Minimizing Defects in Materials Processes 362
17.5 Evaluation of the Presence of Defects 370
17.6 Summary 372
References 372

18 Advanced Direct Forming Processes for the Future

Danjela Kuscer and James Zhijian Shen

18.1 Introduction 375
18.2 Ink-jet Printing Technologies 377
18.3 Laser Sintering 387
Acknowledgments 388
References 389

Index 391