

Index

a

accumulative roll bonding (ARB) 15,
20, 225, 228, 238

additive manufacturing (AM)
 technology
 advantages 256
 architecture design 257
 common devices and
 companies 260
 definition 256
 post-treatment 263
 powder materials 257
 processing methods 259
 surface forming quality 264

Ti-based alloys
 animal experiments 275
 clinical trials 277, 279
 future prospects 278
 in vitro biological evaluation 273
 mechanical properties 267–268
 microstructure 265

alpha iron (α -Fe) 118, 133, 139–141

American Society for Testing and
 Materials (ASTM) 1, 2, 98, 256

annealing 35, 37, 74, 80, 119, 129, 132,
150, 207, 230, 239

antibacterial function 3

antibacterial metallic biomaterials
 bulk metallic glasses 40
 mechanical, corrosion resistance, and
 antibacterial properties 42–43
 metals 31–33
 Mg alloys 39–40
 stainless steels
 Ag 33–34

Ce 36

Cu 34–36

La 36

Ti alloys

 surface-modified Ti alloys 38–39

 Ti–Ag alloys 37

 Ti–Cu alloys 37–38

 TiNiAg alloy 38

artificial aging 69, 80

Ashby-plot 195

atherosclerosis 113, 298

atomic force microscopy (AFM) 36

AZ31B alloy 82, 92

AZ91D Mg alloy 62, 81, 85

b

ball-milling 194, 224, 225, 228, 238

bare-metal stents (BMS) 8, 49

binary Mg alloys 68, 74, 85, 87, 88

binary Zn-based alloys

 biocompatibility 170–174

 degradation behavior 167–168, 170

 mechanical properties 167

 microstructure of 166–167

biomimetic coatings 91–92

bioresorbable scaffolds (BRS) 8

bone-bonding 189, 190

bone replacement implants 211

bulk metallic glasses (BMGs) 40

 atomic packing structure 191

 biodegradable

 Ca-based 207

 Mg-based 202, 205

 Sr-based 209

 Zn-based 208–209

- bulk metallic glasses (BMGs) (*contd.*)
 - designing
 - functional minor alloying elements 209–210
 - glass forming ability 210
 - fabrication 191, 193
 - future biomedical
 - applications 211–213
 - medical devices, manufacturing 211
 - non-biodegradable
 - Fe-based 201
 - Ti-based 197, 199
 - Zr-based 198, 200
 - polarized corrosion curves 196
 - processing methods 194
 - properties 193, 196
 - surface modification 211
 - bulk nanostructured metallic biomaterials
 - CoCrMo alloys 239, 243
 - crystallization from amorphous solids 224
 - future prospects 245
 - mechanical property variation
 - biocorrosion 228
 - corrosion behavior 227–228
 - fatigue behavior 226
 - friction coefficient 226
 - high strength and ductility 228
 - strength and ductility 226
 - Mg alloys 243
 - physical property variation 225
 - processing methods
 - bottom-up 224–225
 - top-down 224–225
 - pure Cu 244
 - pure Fe 244
 - pure Ta 244–245
 - pure Ti 230–231
 - pure Zr 245
 - stainless steel 238, 240
 - structure-property relationship 228
 - Ti-based alloys 235–236
- C**
- ceria nanoparticles 302
 - Co-Cr stents 47–49
 - cold gas dynamicsparing (CGDS) 150–152
 - combustion synthesis technique 255
 - compaction technique 224
 - computer-aid design (CAD) 17, 256, 260, 262, 278
 - Concept Laser Company 259
 - constrained groove pressing (CGP) 225
 - core-and-mantle model 229
 - Coronary stent implantation 8, 15, 46–49, 59, 92
 - critical cooling rate (CCR) 193
 - critical resolved shear stress (CRSS) 74, 88
 - Curie point 118
 - Curie temperature 201, 225
 - cyclic-extrusion-compression 225
 - cylinder covered compression (CCC) 225
- d**
- Debye temperature 225
 - direct metal laser sintering (DMLS) 256, 257, 260
 - dissolution mechanism 63
 - DREAMS 1G 8, 91
 - DREAMS 2G 8, 91
 - drug-eluting stents (DES) 8
 - drug-releasing coatings 91
 - ductile brittle transition temperature (DBTT) 70
- e**
- electrodeposition method 5, 92, 194, 225, 226, 229
 - electroforming 128, 140, 150, 155
 - electron beam melting (EBM) 256–263, 265–268, 271–273, 275–277, 280–284
 - electron work function (EWF) 229
 - Engineering Research Center for Revolutionizing Metallic Biomaterials (ERC-RMB) 98
 - EOS GmbH 259

equal channel angular pressing
(ECAP) 15, 20, 75, 78–80,
83–84, 87, 150, 225–227,
229–230, 233, 235, 238–239,
243–245

essential metallic elements 298, 304

f

Fe-based degradable metallic
biomaterials
applications 155
fabrication technologies
CGDS 151
ECAP 150–151
electroforming 150
MIM 151
3D printing 153
future outlook 154
mechanical properties and corrosion
rate 115–116
surface modification
degradation behavior
regulation 147–150
for improving
biocompatibility 144–147
iron-based composites
compositing with
metals 139–141
compositing with with nonmetallic
materials 141–142
in vitro biocompatibility of 142
Fe-O film 144
flow/temperature sensor 302
friction stir processing (FSP) 225

g

gamma iron (γ -Fe) 118
glass forming ability (GFA) 193,
210–211
grain-boundary sliding (GBS) 78,
228–229
growth restriction factor
(GRF) 70–71

h

Hall-Petch effect 69
Hall-Petch prediction 226

Hank's solution 65, 74, 85, 90, 129,
138–141, 147–148, 151, 164, 168,
171, 181, 198–199, 202–203, 206,
209, 211

HAp (Mn HAp) ceramics layers 146
HA-VSMCs 145
hemochromatosis 118
hemoglobin 114, 117, 118
hexagonally close-packed structure
(HCP) 69, 74, 76
high pressure torsion (HPT) 15, 20,
225, 226, 229–233, 236–238
hot extrusion 75–76, 78, 84, 170
human bones 192–193, 255, 268, 278
human mesenchymal stem cells
(hMSCs) 6
human umbilical endothelial cells
(HUVECs) 6, 139, 140,
144–146, 302
human umbilical vein smooth muscle
cells (HUVSMC) 121

i

IBS scaffold 145–147
inert gas condensation (IGC) 194,
224, 226
in-stent restenosis (ISR) 8, 35,
299, 300
intergranular stress corrosion cracking
(IGSCC) 63
iron-based composites
compositing with metals 139
compositing with non-metallic
materials 141
in vitro biocompatibility 142
iron stents 121–127, 130, 145, 150
 $\text{Ir}_x\text{Ti}_{1-x}$ -oxides 48

l

LaserCUSING 259
laser engineered net shaping
(LENSTM) 5
long-period stacking ordered
(LPSO) 74–77, 80, 81,
88, 97
low-temperature rapid prototyping
technology 296

m

- magnetic susceptibilities 9, 41, 44–47, 201, 209, 245
 - MAGNEZIX® 96
 - mechanical fracture mechanism 63
 - metal injection molding (MIM) 150, 151
 - metal vapor vacuum arc (MEVVA) 144, 147
 - Mg-based alloy
 - bio-activated surfaces
 - biomimetic coatings 91
 - drug-releasing coatings 91
 - bio-compatibility 64
 - bio-degradation
 - dissolution mechanism 63
 - factors affecting 60
 - IGSCC 63
 - in vivo* experiments 60
 - mechanical fracture mechanism 63
 - micro-galvanic corrosion 61
 - reducing corrosion problem 63
 - TGSCC 63
 - challenges 97
 - degradation property 77
 - essential elements
 - Mg–Ca based alloys 84–85
 - Mg–Si based alloys 85
 - Mg–Sr based alloys 85–86
 - high strength
 - Mg–RE based alloys 87–88
 - Mg–Zn-based alloys 87
 - improved corrosion resistance 90
 - in-situ strengthening
 - atomic property 68
 - grain-refinement 69
 - LPSO 74
 - precipitation strengthening 69, 71
 - solid solubility 68
 - solid solution strengthening 69
 - material compositional design 65
 - mechanical property
 - requirements 64
 - mechanical strength 76
 - medical research
 - cardiovascular devices 92
 - orthopedic devices 94
 - opportunities 97
 - post processing
 - heat treatment 80
 - plastic deformation 75
 - SPD, on corrosion behavior 79
 - SPD, on microstructure and mechanical properties 76
 - pure Mg 83
 - special biofunctions 88, 90
 - toxicity and degradation 66
 - Mg-RE-based alloys
 - mechanical and corrosion property 89
 - micro-arc oxidation (MAO) 5
 - microorganisms 3, 31–32
 - MRI compatibility 9
 - ABI alloy 47
 - Nb alloys 46–47
 - traditional metallic biomaterials 44
 - zirconium (Zr) alloys 44–45
 - multi-directional forging 225
- n**
- N-acetyl cysteine-loaded nanotube Ti (NLN–Ti) 7
 - nitinol scaffolds 6
 - nitinol stents 47, 49
- o**
- osseointegration 5–7, 234, 274, 276–277
- p**
- percutaneous coronary intervention (PCI) 113
 - plasma immersion ion implantation and deposition (PIIID) 144
 - plasma nitriding technology 145
 - plasma spraying 255
 - PLGA-coated porous iron (PCPI) 149
 - PLGA-infiltrated porous iron (PIPI) 149
 - poly (lactic-co-glycolic acid) (PLGA) 149
 - poly (lactide-co-glycolide acid) (PLGA) 91

- poly-L-lactic acid (PLLA) 12, 91, 301
 polymeric sponge replacement
 method 255
 polymethyl methacrylate (PMMA) 91, 195
 porous revolutionizing metallic biomaterials 293
 powder leveling 257, 262
 powder materials, AM
 technology 257, 284
 Pt-enhanced radiopaque stainless steel (PERSS) alloys 48
 pulse wave velocity (PWV) 301
 pure iron
 alpha iron 118
 advantages 154
 cold drawing deformation 119
 degradation behavior in physiological environment 119
 delta iron 118
 gamma iron 118
 human body
 absorption 114, 117
 balancing 117
 distribution 114
 physiological function 114
 toxicity 118
 in vitro experiments 121
 in vivo experiments 123
 in human body 114
 in vivo experiments
 advancement 130
 mechanical properties 114
 metabolism and toxicity 114
- r**
- radiopacity 10
 Co-Cr stents 48
 ideal stent 47
 Nb-based alloy 49
 Nitinol stents 49
 Pt-Cr stents 49
 stainless steel stents 48
 Ta stents 49
 rapamycin 302
 rapid prototyping (RP) technique 5, 17, 256, 296
 reciprocating extrusion 225
 repetitive corrugation and straightening (RCS) 225
 revolutionizing metallic biomaterials
 antibacterial function 3
 biocompatibility and biofunctionality 3
 biocorrosion/biodegradation
 behavior 14–16
 evolution of 302
 future development 304
 in-stent restenosis reduction 8
 intelligentization
 biodegradable electronic stent 302
 biosensors/bioelectronics 300
 microchips 300
 RF-driven RLC resonators 300–301
 RF pressure sensor 301
 wireless implantable biodegradable sensors 300
 mechanical properties
 evolution 10–14
 MRI technology 9
 multi-functions
 ISR 299
 self-antibacterial capacity 297
 osteogenesis
 LENSTM 5
 MAO Ti 5
 Mg alloy 7
 nanotopography 6
 nitinol scaffolds 6
 NLN-Ti 7
 RP technique 5
 Zn incorporation 7
 radiopacity 10
 safety and effectiveness,
 biofunctions 17–19
 severe plastic deformation 20
 3D printing 17
 tissue engineering
 chemical composition/inherent structure modification 293
 Mg/PLGA scaffold 295–296
 nanostructure 294

- revolutionizing metallic biomaterials (*contd.*)
 - porous structures 293
 - rapid prototyping (RP) technology 296
 - surface coating technology 293
 - 3D printing 294–295
 - Young's modulus, spinal fixation applications 10
- ROS scavenging 302
- RRAM array 302
- S**
 - selective laser melting (SLM) 256–268, 272, 275, 276, 284
 - severe plastic deformation (SPD) 20, 70, 75, 76, 79–80, 84, 97, 132, 194, 225, 230, 234, 235, 238, 243–245
 - simulated body fluid (SBF) 16, 61, 62, 65, 75, 81, 85, 86, 90, 92, 121, 137–139, 144, 150, 170, 197, 198, 200, 203, 204, 206
 - Sirolimus 8, 91, 94, 145
 - SK4 steel, wear resistance 195
 - solution treatment 80–82
 - space holder technique 255
 - spark plasma sintering (SPS) 139–140, 155, 178, 193, 211, 238
 - stainless steel stents 48
 - stress corrosion cracking (SCC) 63
 - submerged friction stir processing (SFSP) 225
 - surface modified Ti alloys 38–39
- t**
 - T4 treatment 69, 80–81, 83, 88
 - T6 treatment 69, 80–83, 88
 - Ta stents 49
 - ternary Zn-based alloys
 - biocompatibility 178
 - degradation behavior 176, 178
 - mechanical properties 175–176
 - microstructure 174
 - 3-D printing 17, 128, 153–155, 295
 - 316L SS 1, 33, 36, 44, 46–48, 59, 113–114, 123, 129, 131, 136, 138–139, 144, 151–152, 202, 238–239, 244
 - Ti-6Al-4V, mechanical properties 269
 - Ti-based alloys
 - advantages 255
 - AM technology 256
 - medical field 255
 - tissue engineering 17, 60, 284, 294
 - trabecular titanium (TT) 259
 - traditional metallic biomaterials
 - advantages 1
 - mechanical properties 2
 - revolutionizing metallic biomaterials
 - in vitro corrosion properties vs. 16
 - mechanical properties vs. 13
 - transgranular stress corrosion cracking (TGSCC) 63
 - twist extrusion 225
- u**
 - ultimate strength (UTS) 42–43, 70–72, 75, 76, 78, 80, 81, 83, 85, 87, 88, 90, 171, 177
 - ultra-fined grained (UFG) materials 20, 70, 75–76, 78, 223, 227–228, 233, 238
- v**
 - vascular endothelial cells (VECs) 8, 299, 300
 - vascular smooth muscle cells (VSMCs) 8, 145–146, 151, 245, 299, 300
- w**
 - Wigner-Seitz radius 73
- y**
 - Young's modulus 10–11, 223, 228, 235, 238, 255, 272
- z**
 - zinc (Zn)
 - distribution and mobilization in body 162
 - human body
 - distribution and mobilization 162
 - physiological function 162

- Zn-based degradable metallic
 - biomaterials
 - binary 165
 - biocompatibility 170–174
 - degradation behavior 167–170
 - mechanical properties 167
 - microstructure 166–167
 - challenges and
 - opportunities 182–185
- composites 178
 - nanodiamond 182
 - Zn-ZnO composites 178–182
- pure Zn 164
- ternary 174
 - biocompatibility 178
 - degradation behavior 176–178
 - microstructure 174–175
 - mechanical properties 175–176

