

Index

a

- A1, metastable “phase” 283–287
- AAS, *see* atomic absorption spectroscopy
- ab initio* molecular dynamics (MD) simulation 172
- abrasion 76
- absorption spectroscopy, atomic 133
- Ackerson’s approximation 201
- activation
 - energy 120
 - thermal 203
- adaptive mesh generators 339, 342–343
- adsorption 32–33
- aerogel furnace device 41
- Ag
 - Al-based alloys 81–83
 - Cu-based alloys 55, 61–69
- Ag–Cu–Zn 391–395
 - liquidus surface 393
- a4i Materials Image Analysis 255
- Al
 - Al–Ni alloys, *see* Al–Ni alloys
 - Cu-based alloys 55, 60–69
 - interfacial tension 24
 - Nd–Fe–Co–Al 263–276
 - Ti–Al 245–261
- Al-based alloys
 - binary 66
 - growth morphology 40–41
 - immiscible, *see* immiscible Al-based alloys
 - monotectic 3–17
 - soft metals 19
 - ternary 6–10
- Al–Bi–Cd 104
- Al–Bi–Cu 9–10
- Al–Bi–Cu–Sn 11–15
- Al–Bi–Sn 6–8
- Al–Bi–Zn 6
- Al–Cu
 - eutectic composition 80–81
 - spacing selection 379
- Al–Cu–Ag, invariant eutectic composition 81–83
- Al–Fe 66–68
- Al–Mg–Cu 382
- Al–Ni alloys 66–68, 148–154, 367–369, 376–378
 - entropy and free enthalpy 165–168
 - mixing tendency 136–137
- Al–Pb 89–90
- Al–Sn–Cu 8–9
- algorithms and software
 - adaptive mesh generators 339, 342–343
 - a4i Materials Image Analysis 255
 - computer-aided design (CAD) 76
 - edge detection 59
 - FIT2D 192
 - FLUENT 77
 - force biased 172–173
 - Metropolis method 145
 - MICRESS 376, 389
 - Monte Carlo simulation, *see* Monte Carlo simulation
 - Nelder–Mead 173, 177
- alloy melts
 - crystal growth 157–170
 - glass-forming 118–119
 - see also* melts
- alloys
 - Al-based, *see* Al-based alloys
 - amorphous 177–178, 263
 - binary, *see* binary alloys
 - Cu-based, *see* Cu-based alloys
 - hypermonotectic 51
 - interstitial 88
 - melting 312–316

- alloys (*contd.*)
 —Nd-Fe-based, *see* Nd-Fe-based alloys
 —phase equilibria 87–107
 —ternary, *see* ternary alloys
- amorphous alloys 263
 —Cu-Zr 177–178
- anisotropic chemical capillary lengths 318
- anisotropy
 —magnetocrystalline 87, 245
 —multicomponent multiphase systems 327
 —PF simulations 217, 221–223
- annealing 91
 —LC method 134
 —modeling 164–165
 —Zr-Ti-Nb-Cu-Ni-Be 418
- antisymmetric approximation 367
- antitrapping flux 375
- approximation
 —Ackerson's 201
 —antisymmetric 367
 —dilute solution 303
 —“lubrication” 314
 —Percus-Yevick 121–123
 —Würth's 201
- arbitrary phase diagrams 325
- arc melting 278
- arm spacing, secondary dendritic 252–255
 —secondary dendritic 259
- Arrhenius fit 117
- Arrhenius plot 137, 204–205
- ARTEMIS facility 41–42
- as-cast sample 417
- as-quenched composite 410
- Asaro-Tiller-Grinfeld (ATG) instability 319, 321
- asymmetry energy 31
- atmosphere, protecting 58
- atomic absorption spectroscopy (AAS) 133
- atomic attachment 356
 —kinetics 111
- atomic diffusion 111–129, 413–414
- atomic dynamics
 —liquid Ni 115–118
 —Ni-P-based alloy melts 118–119
 —Zr-based alloys 119–120
- atomic radius, metals 178
- atomic size distribution 179
- atomic volume 149–150, 153
- atomistic first-principles calculations 157
- Avrami model, Kolmogorov-Johnson-Mehl-203
- azeotrope phase diagram 196
- azimuthal flow 247
- b**
- B (boron), *see* Nd-Fe-B
- back-scattered electron (BSE) contrast 6–9, 14
- ball-milled material 90–92
- barrier-crossing 204
- basic phase-field equation 373
- bcc dendrites 414
- Be
 —Zr-Ti-Nb-Cu-Ni-Be 407–420
 —Zr-Ti-Ni-Cu-Be 119–120
- bearings, self-lubricating 19
- Bernal's liquids, multicomponent 171–183
- Bhatia-Thornton formalism 120–122
- Bi
 —Al-based alloys 104
 —Al-Bi 40–41
 —Al-Bi-Cu-Sn 11–15
 —In-Bi-Sn 395–400
 —interfacial tension 24
 —ternary alloys 6–11
- Bi-Cd 101–103
- Bi-Cu-Sn 11
- bifurcation 299
- bimodal curve 40
- binary Al-based alloys 66
- binary alloys 40–41
 —compositional stresses 299–309
 —constitutional effects 362–366
 —diffuse-interface model 362
 —eutectic composition 80–81
 —rapid quenching 280–288
 —sharp-interface model 362–364
 —simulation 141–156
 —solidification 362–366
 —solute trapping 363
 —spacing selection 379–381
- binary colloidal crystals, growth 199–202
- binary colloidal melts, solidification 185–211
- binary data sets, thermodynamic extrapolation 11
- binary eutectic growth 390
- binary eutectic phase diagram 388
- binary interaction parameters 62
- binary melts 112
- binary nanoalloys 97–105
- Blackburn, sum rule of Cummings and 59
- BMGs, *see* bulk metallic glasses
- boron, *see* Nd-Fe-B
- boundary groove, *see* “grain boundary groove in an applied temperature gradient” method
- boundary layer, solutal 343
- Bragg peaks 410
- Bragg reflection 91, 199

- branching regime 323
 Brener theory 341, 359
 Bridgman experiments 391
 —micro-Bridgman assembly 396–398, 401
 Bridgman furnace 82
 BSE, *see* back-scattered electron . . .
 bulk metallic glasses (BMGs) 171
 —Zr–Ti–Nb–Cu–Ni–Be 407–420
 buoyancy convection 373–385
 —gravity-driven 112, 117
 —PF modeling 373–376
 buoyancy-driven interdendritic flow, directional solidification 378–383
 Burgers circuit 93–95
 Butler equation 57, 65
- c**
- Cahn and Hilliard model 31
 calibration
 —diffusion data 402–403
 —interfacial energies 403–404
 calibration of parameters 325
 calorimetric melting 102–103
 calorimetry, differential scanning, *see* differential scanning calorimetry
 Calphad method 391–393, 405
 —PF modeling 157, 376
 —thermodynamic modeling 3, 16
 capillarity, Young–Laplace equation 21–23
 capillary, graphite 132
 capillary constant 22–23
 capillary lengths 316–318
 capillary method, long-, *see* long-capillary method
 capillary supercooling 48
 capillary term 99
 casting
 —*as-cast* sample 417
 —Cu mold, *see* Cu mold casting
 casting industry 353
- Cd**
- Al-based alloys 104
 —Al–Cd 40–41
 —Bi–Cd 101–103
- cell, Voronoi-like 43
 cellular structure 299
 centrifugal Cu mold casting 279
 charge, effective 189
 charge density, surface 195
 charge variable systems 193–196
 charged colloidal suspensions, tunable interactions 186–190
 charged sphere mixtures 196–199
- chemical capillary lengths, anisotropic 318
 “chemical” dendrites 354
 chemical diffusion, *see* interdiffusion
 —Peclet number 367
 chemical reactions, invariant 13
 chromium, *see* Cr
 circuit, Burgers 93–95
 classical nucleation theory (CNT) 19–20
 —binary colloidal crystals 200, 203–207
 —undercooled melts 240–241
- clusters
- crystal-like 207
 —interdendritic 415
 —Mackay 176
- Co**
- binary alloys 66–68
 —Cu-based alloys 55, 61–69
 —Nd–Fe–Co–Al 263–276
- co-focal parabolic fronts 317
 coarse-grained microstructure 364–366
 coercive field strength 245
 coexisting phases 100
 coherency strain 316
 —elastic energy 318
 colloidal crystals, binary 199–202
 colloidal melts, solidification 185–211
 computer-aided design (CAD) 76
 concentration dependence, solid-liquid interface energy 83–84
 concentration profiles 412
 —planar crystallization front 163–165
 concentric heater 24
 conductivity, thermal 74
 —thermal 81–82
 configuration entropy 167–168
 congruently melting Ni–Al 359–361
 conservation laws 330–332, 354–355
 constitutional effects, binary alloys 362–366
 container scattering 114
 continuum theory, fast crack propagation 319–323
- contrast
- BSE 6–9, 14
 —magnetic 272
 —topological 290
- convection
- buoyancy-driven 373–385
 —electromagnetically induced 231
 —gravity-driven buoyancy 112, 117
 —hydrodynamic 217–220
 —nonisothermal systems 325–338
 —rolls 251, 383
 —varying 245–261

- convective flow, dendrite growth 358
- convective PF modeling 330–336
- convergence behavior, dendrite growth velocity 377
- cooling conditions, nonequilibrium 289
- cooling rate, rapidly quenched Nd–Fe 280–283
- coordination number 121, 178
- copper, *see* Cu
- correlation functions, partial pair 148–149
- correlation length, ferromagnetic 87
- Coulomb potential 185
- counterions 186
- counting experiments, microscopic 203
- coupled growth 53, 398–400
- crucible rotation 247–248
- crystal growth 73
 - binary colloidal crystals 199–202
 - crystal–liquid interfaces 154
 - MD simulation 157–170
- crystal-like clusters 207
- crystal–liquid interfaces 152
 - mass diffusion controlled crystal growth 154
- crystallization
 - Al–Ni alloys 148–154
 - nano- 407
 - planar front 162–165
 - single step 235
 - thermodynamics 158–162
- crystals
 - binary colloidal 199–202
 - quasi- 414–418
- Cu 119–120
 - Ag–Cu–Zn 391–395
 - Al-based alloys 11–15, 80–83, 379, 382
 - interfacial tension 24
 - Ni–Cu–Cr 344
 - Pd–Cu–Ni–P 118, 137–139
 - ternary alloys 8–11
 - Zr–Nb–Cu–Ni–Al 408
 - Zr–Ti–Nb–Cu–Ni–Be 407–420
- Cu-based alloys 55
- Cu–Co 66–68
- Cu mold casting 264, 278–279
- Cu–Ni 66–68
- Cu–Zr amorphous alloy 177–178
- “cube-on-cube” orientation 95
- cubic anisotropy 327
- Cummings and Blackburn, sum rule of 59
- Curie temperature
 - hard magnetic glasses 263
 - Nd–Fe–B 251
- curvature
 - interface 320
 - local 75–79
- d**
 - Darken equation 142
 - Darken–Manning equation 131, 135–136
 - Debye–Hückel potential 186
 - Debye–Waller factor 122
 - decomposition, Zr–Ti–Nb–Cu–Ni–Be 407–420
 - deformation, plastic 258
 - deionized conditions 194
 - deionized mixture 206
 - demagnetization curves, room-temperature 287–288
 - demixing
 - liquid–liquid 141
 - multiple 3
 - Pd–Cu–Ni–P 137–139
 - dendrite growth 236–240
 - convective flow 358
 - directional 380
 - Nd–Fe–B 252–255
 - Ni–Cu–Cr 344
 - Ni–Zr 343
 - PF modeling 341–345
 - Rayleigh-like instability 364
 - undercooled melts 353–372
 - velocity 231, 241, 377
 - dendrite–matrix interface 411–412
 - dendrites
 - bcc 414
 - “chemical” 354
 - dendritic arm spacing, secondary 252–255
 - secondary 259
 - dendritic microstructure 382, 407–420
 - dendritic precipitates 415
 - dendritic solidification
 - diffuse regime 373–385
 - PF modeling 373–376
 - dense random packing 175–176
 - density 56
 - correlation functions 116
 - elastic energy 302
 - measurement 59
 - scattering length 272–273
 - surface charge 195
 - surface energy 329
 - surface entropy 340–341
 - devitrification process 416
 - differential scanning calorimetry (DSC)
 - interfacial tension 24–26
 - morphology formation 396

- solid-liquid interface energy 81
- ternary alloys 4, 6–7
- Zr–Ti–Nb–Cu–Ni–Be 408–411, 413–414
- differential sedimentation 198
- differential thermal analysis (DTA), Al-based alloys 8
 - Al-based alloys 12–14
- diffraction
 - selected area electron 285–287
 - X-ray, *see* X-ray diffraction
- diffraction patterns 191–192, 288–289
- diffuse-interface model 341
 - binary alloys 362
 - one-component systems 354–356
 - ternary alloys 366–367
- diffusion
 - atomic 111–129, 413–414
 - chemical, *see* interdiffusion
 - data calibration 402–403
 - experimental techniques 132–135
 - influence of thermodynamic forces 135–139
 - inter-, *see* interdiffusion
 - multicomponent metallic melts 131–140
 - solid phase 316
 - surface 300
- diffusion capillary, graphite 132
- diffusion coefficients
 - PF simulations 403
 - self-, *see* self-diffusion coefficients
- diffusion equation, multicomponent 375
- diffusion-limited solidification 369
- diffusion potential 302
- diffusion velocity, lateral 52
- diffusionless processes 323
- diffusivity, self- 111
- dilute solution approximation 303
- directional dendritic growth 380
- directional solidification 51, 299
 - buoyancy-driven interdendritic flow 378–383
 - ternary eutectic alloys 387–406
- discontinuous morphology 285
- dislocations, edge 95–96
- displacement, mean-squared 143
- dissipation
 - PF dynamics 322
 - viscous 356
- domains, magnetic 267–273
- double convection rolls 251
- double-tangent construction 159–160
- droplets
 - critical radius 20
 - irregularly spaced 45
- drops, irregular 50–53
- DSC, *see* differential scanning calorimetry
- DTA, *see* differential thermal analysis
- Du Noüy ring method 21
- duplex microstructure 245
- dynamics
 - dissipative phase-field 322
 - macroscopic/microscopic 111–214
 - Ni–Zr crystallization front 162–165
- e**
- edge detection algorithm 59
- edge dislocations 95–96
- EDX, *see* energy-dispersive X-ray spectrometry
- EELS, *see* electron energy loss spectroscopy
- effective charge 189
- effective interface thickness 305
- effective mobility 374
- Einstein relation, Stokes– 126
- Ekman number 247–248, 253
- elastic coherency strain energy 318
- elastic constants 301–304
- elastic effects, phase transitions 311–324
- elastic energy, coherency strain 318
- elastic energy density 302
- elastic moduli 96
- elastic neutron scattering 115
- “elastic vacuum” 319
- electromagnetic levitation 58, 114–117, 353, 359–360
 - undercooled melts 228
- electromagnetic pump effect 249
- electromagnetic stirring 246
- electromagnetically induced convection 231
- electromagnetically processed melts 353
- electron diffraction, selected area 285–287
- electron energy loss spectroscopy (EELS) 89
- elemental solids 97
- energy
 - activation 120
 - asymmetry 31
 - elastic 318
 - free-energy functional 217, 305
 - Gibbs, *see* Gibbs energy
 - Gibbs free 99–100
 - Ginzburg–Landau 327–330
 - interfacial 31, 328
 - magnetic 263–264
 - pair interaction 186
 - solid-liquid interfaces, *see* solid-liquid interface

- energy
 - energy density
 - elastic 302
 - surface 329
 - energy-dispersive X-ray spectrometry (EDX) 133, 236, 252
 - rapidly quenched alloys 280–283, 286, 290–293
 - ensemble, semi-grandcanonical 142
 - semi-grandcanonical 145
 - enthalpy
 - free, *see* free enthalpy
 - of formation 392
 - temperature dependence 159
 - entropy
 - Al–Ni–Zr 165–168
 - configuration 167–168
 - multicomponent multiphase systems 327, 340–341
 - Ni–Zr 158–162
 - structural 167–168
 - surface density 340–341
 - vibration 159
 - entropy inequality 329–332
 - entropy of fusion 73, 79
 - equations of motion
 - compositional stress 301–304
 - Newton’s 141, 319
 - equiaxed-grain-refined microstructure 364
 - equilibration, samples 75
 - equilibrium, local 314
 - equilibrium partition coefficient 162
 - Euler–Lagrange equations 328
 - eutectic alloys, ternary 387–406
 - eutectic composition
 - Al–Cu system 80–81
 - invariant 81–83
 - eutectic grooves, univariant 403
 - eutectic growth 346–350, 390
 - eutectic Nd grains, fibrous 281–283
 - eutectic phase diagram 347, 388
 - eutectic point, invariant ternary 389
 - eutectic systems
 - Jackson–Hunt model 39, 46–48
 - melting in 312–316
 - phase diagrams 312
 - ternary 349
 - “eutectic” temperature 104
 - expansion, thermal, *see* thermal expansion
 - extended sharp interface theory 240
 - external interfaces, single-phase material 88–97
 - extrapolation
 - Redlich–Kister/Muggianu-type 12
 - thermodynamic 11
- f**
 - Faber–Ziman formalism 120–122
 - facetted anisotropy 327
 - facetted nucleus 222
 - fast crack propagation, continuum theory 319–323
 - fcc short-range order 175–176
 - Fe
 - Cu-based alloys 55, 61–69
 - Nd–Fe 280–288
 - Nd–Fe-based alloys, *see* Nd–Fe-based alloys
 - Nd–Fe–Co–Al 263–276
 - Nd–Ga–Fe 288–295
 - γ -Fe 227–240
 - Fe–Ni 66–68
 - ferromagnetic correlation length 87
 - fibrous binary eutectic growth 390
 - fibrous eutectic Nd grains 281–283
 - fibrous monotectic growth 47–48
 - Fick’s laws 131
 - Fick’s second equation 133
 - field strength, coercive 245
 - filtering, Fourier 91
 - Fourier 93
 - finite system size 101
 - first-order phase transitions 88
 - first-principles calculations 157
 - FIT2D 192
 - fivefold symmetry 172
 - fixed-charge single-component systems 186
 - floating zone facility 248–251
 - flow, heat, *see* heat flow
 - fluctuations, magnetization 267
 - FLUENT 77
 - fluid flow, buoyancy-driven 381–383
 - fluid flow coupling 375–376
 - force biased algorithm 172–173
 - forced rotation technique 246–248
 - forces
 - Lorentz 247
 - thermodynamic 135–139
 - form factors 266
 - foundry industry 353
 - Fourier filtering 91, 93
 - Fourier’s law 74
 - fourth-order cumulant 145–146
 - free energy
 - Gibbs 99–100
 - multicomponent multiphase systems 326

- nucleation 220–221
- free-energy functional 217, 305
- free enthalpy
 - Al–Ni–Zr 165–168
 - Ni–Zr 158–162
- free-surface phenomena 247
- Frenkel law, Wilson– 200–201
- Frenkel model, Wilson– 142
 - Wilson– 153
- Freundlich-type equations,
 - Gibbs–Thompson– 98
- fringes, Moiré 89
- front
 - co-focal parabolic 317–318
 - planar 162–165
 - solidification 44–45
- full phase diagram, charge variable systems 193–196
- furnace
 - aerogel 41
 - Bridgman 82

g

- Ga, Nd–Ga–Fe 288–295
- gap, ternary miscibility 5–7
- Gauss–Seidel smoothing operator 306–307
- geometrical correction, groove coordinates 76–77
- getter, niobium 24
- Gibbs adsorption 32
- Gibbs energy
 - surface tension 57
 - ternary alloys 6, 11–12
- Gibbs free energy 99–100
- Gibbs’ phase rule 98
- Gibbs–Thompson–Freundlich-type equations 98
- Gibbs–Thomson coefficient 79–83
- Gibbs–Thomson equation 78–79, 299–300, 340
- Gibbs triangle 388, 395
- Ginzburg–Landau energy, multiphase 327–330
- glass-forming ability 407
- glass-forming alloy melts 118–119
- glass matrix composite 407–420
- glasses
 - bulk metallic, *see* bulk metallic glasses
 - hard magnetic 263–276
- global packing fraction 177
- goniometer 190
- “grain boundary groove in an applied temperature gradient” method 73

- grain refinement, undercooled melts 353–372
- grains, fibrous eutectic Nd 281–283
- graphite diffusion capillary 132
- gravity, reduced 360
- gravity-driven buoyancy convection 112, 117
- Green–Kubo relations 144
- Griffith point 320
- grinding 76
- Grinfeld instability 301
 - Tiller–Asaro– 319, 321
- grooves
 - coordinates 76–77
 - eutectic 403
 - grain boundary 75–79
- growth
 - binary colloidal crystals 199–202
 - coupled 53
 - crystal, *see* crystal growth
 - dendritic, *see* dendrite growth
 - eutectic, *see* eutectic growth
 - peritectic 215–225
 - stationary 398–400, 403–404
 - three-phase coupled 400
 - transient 400–404
- growth kinetics 215–225
- growth morphology 39–54, 216
- growth velocity 199–200
 - Ni–Zr 362–364
 - Ni–Zr–Al 367–369

h

- hard magnetic glasses 263–276
 - microstructure 268
- hard magnetic phase
 - A1 zones 290–292
 - microstructure evolution 245
 - Nd–Fe–B 227–240
- hard sphere model 123
 - Bernal’s 175–176
- head crystal 198
- heat flow, radial 74
- heat of mixing, negative 171
- heat transport equation 356
- heater, concentric 24
- heterogeneous nucleation, PF modeling 220–223
- heterophase interfaces, internal 97–105
- hexagonal lattice 43
- hexagonal phase, Ni–Fe 284
- hexagonal rod-like structure 349
- high-pressure torsion straining 92
- Hilliard, model of Cahn and 31
- holes, icosahedral 12-neighbor 166

- homogeneous nucleation 203
- Hooke's law 303, 320
- hopping processes 119
- Hückel potential, Debye– 186
- Hunt . . . , *see* Jackson–Hunt . . .
- hydrodynamic convection, PF modeling 217–220
- hyperbolic tessellation 174
- hypermonotectic alloys 51
- hysteresis 265, 287–288, 291

- i**
- icosahedral 12-neighbor holes 166
- icosahedral short-range order 123, 175–176
- ICP-MS, *see* inductively coupled plasma MS
- ideal solid solution 197
- ideal solutions 61–62
- immiscible Al-based alloys, interfacial tension 19–38
- In, Al–In 40–41
- In–Bi–Sn 395–400
- in situ* X-ray radiography 112
- inclusions, liquid 311
- incoherent scattering 113
- induction melting 257
- inductively coupled plasma MS (ICP-MS) 133, 138
- inherent structure approach 169
- instability
 - Asaro–Tiller–Grinfeld 319, 321
 - Grinfeld 301
 - Mullins–Sekerka 301
 - Rayleigh 39, 364
- instationary morphology formation 387–406
- insulator, thermal 41
- integral enthalpy of formation 392
- interactions, tunable 186–190
- interdendritic cluster 415
- interdendritic convection rolls 384
- interdendritic flow, buoyancy-driven 378–383
- interdendritic liquid 365
- interdendritic region 6, 381
- interdiffusion 131, 367
- interdiffusion coefficients 124
 - Arrhenius plot 137
 - vanishing 142
- interdiffusion constant 143
- interface curvature 320
- interface mobility 162, 230
- interface thickness, effective 305
- interface velocity 153
- interfaces
 - crystal–liquid 154
 - crystal–melt 152
 - dendrite–matrix 411–412
 - diffuse 341
 - extended sharp interface theory 240
 - external 88–97
 - internal heterophase 97–105
 - “ordered” 89
 - particle–matrix 98
 - sharp-interface model, *see* sharp-interface model
 - solid-liquid, *see* solid-liquid interfaces
 - static 163
 - stretching 300
- interfacial energy 31, 328
 - calibration 403–404
 - γ phase nucleation 238
- interfacial segregation 98
- interfacial tension
 - and miscibility gap 31–33
 - composition dependence 30–32
 - liquid-liquid 19–38
- intergrowth 15
- intermetallic compounds, formation 69
- intermetallic phases, superlattice structure 240
- internal heterophase interfaces 97–105
- interstitial alloys 88
- invariant eutectic composition, Al–Cu–Ag 81–83
- invariant reactions, Al–Bi–Cu–Sn system 13
- invariant ternary eutectic point 389
- inverse relaxation time 116
- iron, *see* Fe
- irregular drops 50–53
- irregularly spaced droplets 45
- irreversible thermodynamics 332
- Ising behavior 146–147
- isothermal melting 313–316
- isothermal section 394, 397
- isothermal surface tension curves 66
- isothermally undercooled melt 348
- isothermals 80
- isotropic scattering 266

- j**
- jacket, water cooled 74
- Jackson–Hunt constant 49–50
- Jackson–Hunt model 39, 46–48, 404
- Jackson–Hunt plot 45–46
- Johnson–Mehl–Avrami model, Kolmogorov–203
- Jones, *see* Lennard–Jones . . .

k

Karma corrections 374–375
 kinetic coefficient, *see* interface mobility
 kinetic undercooling 367
 kinetics
 —atomic attachment 111
 —growth 215–225
 —nucleation 203–206, 215–225
 —phase-field (PF) 355
 Kissinger method 418
 Kister form, Redlich– 58
 Kister/Muggianu, *see*
 Redlich–Kister/Muggianu-type
 extrapolation
 Kolmogorov–Johnson–Mehl–Avrami model
 203

l

Lagrange equations, Euler– 328
 Lagrange multiplier 326, 333
 lamellar eutectic growth 349–350
 lamellar microstructures 389
 Landau energy, Ginzburg– 327–330
 Laplace equation 314, 317
 —Young–, *see* Young–Laplace equation
 lateral diffusion velocity 52
 lattice, hexagonal 43
 laws and equations
 —basic phase-field equation 373
 —Butler equation 57, 65
 —conservation laws 330–332, 354–355
 —Darken equation 142
 —Darken–Manning equation 131,
 135–136
 —entropy inequality 329–332
 —equations of motion 301–304
 —Euler–Lagrange equations 328
 —Fick’s laws 131
 —Fick’s second equation 133
 —Fourier’s law 74
 —Gibbs’ phase rule 98
 —Gibbs–Thompson–Freundlich-type
 equations 98
 —Gibbs–Thomson equation 78–79,
 299–300, 340
 —Green–Kubo relations 144
 —heat transport equation 356
 —Hooke’s law 303, 320
 —interface mobility 230
 —interfacial energy 328
 —Laplace equation 314, 317
 —modified Navier–Stokes equation
 218

 —multicomponent diffusion equation
 375
 —Navier–Stokes equation 355
 —Newton’s equation of motion 319
 —Newton’s equations of motion 141
 —Ornstein–Zernicke form 147
 —Porod law 268, 274–275
 —Reynold’s transport theorem
 330–331
 —scattering law 114
 —second law of thermodynamics
 332–336
 —Stokes–Einstein relation 126
 —stress–strain relationship 302
 —sum rule of Cummings and
 Blackburn 59
 —Vegard’s law 56
 —Wilson–Frenkel 153, 200–201
 —Young–Laplace equation of capillarity
 21–23
 —*see also* model, theory
 layer structure, two-phase 161
 lead, *see* Pb
 Legendre polynomials 59
 lengths, capillary 316–318
 Lennard–Jones (LJ) mixture, symmetric
 144–148
 levitation, electromagnetic 58, 114–117, 228,
 353, 359–360
 levitation coil 114
 light scattering, static 190–193
 liquid film migration (LFM) 311–313,
 316–318
 liquid inclusions 311
 liquid–liquid demixing 141
 liquid–liquid demixing transition 144–148
 liquid–liquid interfaces, adsorption 32–33
 liquid–liquid interfacial tension 19–38
 —composition dependence 30–32
 —temperature dependence 33
 liquid Ni, atomic dynamics 115–118
 liquid–solid interfaces, *see* solid–liquid
 interfaces
 liquid Zr–Ni, short-range order 120–124
 liquids
 —Bernal’s 171–183
 —interdendritic 365
 —mass transport 111
 —metastable 117
 —monoatomic 175–177
 —solid–liquid interfaces, *see* solid–liquid
 interfaces
 liquidus curve 52, 160, 162
 liquidus slope 303–304

- liquidus surface 6–8, 10–11, 393
 - liquidus temperature 56
 - LJ, *see* Lennard–Jones ...
 - local curvature, grain boundary grooves 75–79
 - local equilibrium, liquid–solid interfaces 314
 - local packing fraction 174
 - local undercooling 77–78
 - long-capillary (LC) method 132–134
 - simulation 150
 - X-ray radiography 134–135
 - Lorentz force 247
 - lubrication, self- 19
 - “lubrication” approximation 314
- m**
- Mackay cluster 176
 - macroscale modeling 162
 - macroscopic dynamics 111–214
 - magnetic contrast 272
 - magnetic domains 267–273
 - size 271
 - magnetic energy 263–264
 - magnetic field, floating zone facility 248–251
 - magnetic form factors 266
 - magnetic glasses 263–276
 - magnetic phase
 - hard, *see* hard magnetic phase
 - soft, *see* soft magnetic phase
 - magnetic SLD 272–273
 - magnetic systems, unsaturated 265–268
 - magnetization
 - density profiles 263–276
 - fluctuations 267
 - temperature dependence 264
 - magnetocrystalline anisotropy 87, 245
 - magnetometer, vibrating sample 251, 255, 280
 - magnets
 - Nd–Fe–B 245
 - two-phase 292
 - Manning equation, Darken– 131
 - Darken– 135–136
 - Manning factor 136, 144
 - simulation 151
 - Marangoni motions 19
 - mass conservation 330
 - mass diffusion, controlling crystal growth 154
 - mass spectrometry (MS), inductively coupled plasma 133
 - inductively coupled plasma 138
 - mass transport, liquids 111
 - matrix interfaces 98, 411–412
 - matrix strains 97
 - MD, *see* molecular dynamics
 - Mead algorithm, Nelder– 173
 - Nelder– 177
 - mean-squared displacement 143
 - Mehl–Avrami model, Kolmogorov–Johnson–203
 - melt spinning 279
 - melt structure 111–129
 - melting 88
 - arc 278
 - calorimetric 102–103
 - combined motion of fronts 316–318
 - eutectic and peritectic systems 312–316
 - induction 257
 - isothermal 313–316
 - melting point 56
 - melting temperature 131–140
 - melts
 - alloy, *see* alloy melts
 - buoyancy-driven convection 373–385
 - colloidal, *see* colloidal melts
 - congruent 359–361
 - electromagnetically processed 353
 - glass-forming 118–119
 - isothermally undercooled 348
 - multiphase 3–108
 - Ni–Zr 158–162
 - undercooled 206–207
 - varying convection 245–261
 - meniscus volume 22
 - meridional flow 247
 - mesh generators, adaptive 339
 - adaptive 342–343
 - mesoscale modeling 162
 - metallic glasses 407–420
 - bulk, *see* bulk metallic glasses
 - metallic melts, multicomponent, *see* multicomponent metallic melts
 - metals
 - atomic radius 178
 - nanoscale 87–107
 - soft 19
 - transition 68
 - metastable A1 “phase” 283–287
 - metastable hard magnetic A1 zones, tuning 290–292
 - metastable liquids 117
 - metastable χ phase 227–240
 - metastable phase formation 407–420
 - Metropolis method 145
 - Mg, Al-based alloys 382

- MICRESS 376, 389
 micro-Bridgman assembly 396–398
 —transient growth 401
 microexamination 75
 microgravity 112, 117
 micromagnetic model of domains 266
 microscopic counting experiments 203
 microscopic dynamics 111–214
 microscopic temperature field, simulation 77
 microscopic transport processes, simulation 141–156
 microstructure
 —coarse-grained 364–366
 —dendritic 382, 407–420
 —duplex 245
 —equiaxed-grain-refined 364
 —hard magnetic glasses 268
 —monotectic growth 42–45
 —Nd–Fe–B 278
 —peritectic alloys 245–261
 —rapidly quenched Nd–Fe 280–283
 migration, liquid film 311–313
 —liquid film 316–318
 Miller indices 193
 milli-Q water 190
 miscibility gap 5–7, 31–33
 mixing
 —Al–Ni 136–137
 —negative heat of 171
 mixtures
 —charged spheres 196–199
 —deionized 206
 —organic 34–35
 mobility
 —effective 374
 —interface 162, 230
 mode coupling theory 119, 124–125
 —critical temperature 152
 —self-diffusion coefficients 124–125
 model
 —Bhatia–Thornton formalism 120–122
 —Cahn and Hilliard 31
 —diffuse-interface, *see* diffuse-interface model
 —Faber–Ziman formalism 120–122
 —hard sphere 123
 —Jackson–Hunt 39, 46–48, 404
 —Kolmogorov–Johnson–Mehl–Avrami 203
 —micromagnetic 266
 —multilayer 35
 —negentropic 229
 —nucleation and dendrite growth 236–240
 —sharp-interface, *see* sharp-interface model
 —spherical cap 216
 —two-phases 169
 —Wilson–Frenkel 142
 —*see also* laws and equations, theory
 modeling
 —annealing 164–165
 —Calphad method, *see* Calphad method
 —macro-/mesoscale 162
 —nonisothermal systems with convection 325–338
 —PF, *see* phase field modeling
 modified Navier–Stokes equation 218
 Moiré effect 103
 Moiré fringes 89
 molar Gibbs free energy 99
 mold casting, Cu, *see* Cu mold casting
 molecular dynamics (MD) simulation 141–142, 147
 —*ab initio* 172
 —and phase field modeling 162–165, 345–346
 —crystal growth 157–170
 —numerical reliability 166–167
 molecular layers, solid–liquid interface 215
 monoatomic liquids, computational optimization 175–177
 monotectic alloys, Al-based 3–17
 monotectic growth 39–54
 —fibrous 48–50
 monotectic phase diagrams 4–5
 Monte Carlo simulations 142, 145, 147
 —nucleation kinetics 221
 morphological stability, solid–liquid interfaces 299
 morphology formation, (in)stationary 387–406
 motion
 —combined, *see* combined motion
 —equations of, *see* equations of motion
 —Stokes/Marangoni 19
 —tagged particles 143
 MS, *see* mass spectrometry
 Muggianu, *see* Redlich–Kister/Muggianu-type extrapolation
 Mullins–Sekerka instability 301
 multicomponent alloys
 —elastic effects 311–324
 —monotectic Al-based 3–17
 —surface tension 55–71
 —thermal expansion 55–71

- multicomponent Bernal's liquids 171–183
- multicomponent diffusion equation 375
- multicomponent immiscible Al-based alloys 19–38
- multicomponent metallic melts 111–129
 - diffusion 131–140
- multicomponent multiphase systems 325–338
 - anisotropy 327
 - free energy 326
 - PF modeling 326–327
 - solidification 339–351
- multilayer model 35
- multiphase Ginzburg–Landau energies 327–330
- multiphase melts, thermodynamics 3–108
- multiple demixing 3
- multiple scattering 115
- multiplier, Lagrange 326
 - Lagrange 333
- n**
- nanoalloys, binary 97–105
- nanocrystalline phase 285–287, 290
- nanocrystallization 407
- nanoparticles 91–95, 268–273
- nanoscale metals, phase equilibria 87–107
- nanosized magnetization density profiles 263–276
- Navier–Stokes equation 218, 355
- Nb
 - Zr–Nb–Cu–Ni–Al 408
 - Zr–Ti–Nb–Cu–Ni–Be 407–420
- Nb getter 24
- Nd, oxide formation 252
- Nd–Fe 280–288, 287–288
- Nd–Fe–B
 - Curie temperature 251
 - dendrite growth 252–255
 - forced rotation experiments 252–256
 - hard magnetic phase 227
 - magnets 245
 - microstructure 278
 - microstructure evolution 245–261
 - nonperitectic 236
 - PF simulations 215–225
 - undercooled melts 227–244
- Nd–Fe-based alloys 215–295
- Nd–Fe–Co–Al 263–276
- Nd–Ga–Fe 288–295
 - soft magnetic phase 291–292
- Nd grains, fibrous eutectic 281–283
- Nd nanoparticles 268–273
 - radius 270
- nearest neighbor coordination number 121
- negative heat of mixing 171
- negentropic model 229
- 12-neighbor holes, icosahedral 167
- Nelder–Mead algorithm 173, 177
- Nelder–Mead simplex 173, 180
- neutral curves 304–305
- neutron scattering 113–115
 - simulation 150
 - small-angle 265–268, 409
 - structure factors 207
- neutrons, polarized 265–268
 - polarized 270
- Newton's equations of motion 141, 319
- Ni
 - Al–Ni alloys 136–137, 148–154
 - Al–Ni–Zr 165–168
 - binary alloys 66–68
 - dendrite growth and grain refinement 356–359
 - liquid 115–118
 - Pd–Cu–Ni–P 118, 137–139
 - Zr-based alloys 119–120
 - Zr–Nb–Cu–Ni–Al 408
 - Zr–Ti–Nb–Cu–Ni–Be 407–420
- Ni–Al, congruently melting 359–361
- Ni–Al–Zr, rapid solidification 376–378
- Ni–Cu–Cr, dendrite growth 344
- Ni–Fe 277, 284
- Ni–P-based glass-forming alloy melts 118–119
- Ni–Zr
 - crystallization front dynamics 162–165
 - dendrite growth 343
 - entropy and free enthalpy 158–162
 - growth velocity 362–364
 - phase diagram 158, 161–162
- Ni–Zr–Al, growth velocity 367–369
- niobium, *see* Nb
- nonequilibrium cooling conditions 289
- nonisothermal PF simulations 343
- nonisothermal systems 325–338
- nonperitectic Nd–Fe–B 236
- nuclear form factors 266
- nucleation
 - classical theory, *see* classical nucleation theory
 - free energy 220–221
 - heterogeneous 220–223
 - kinetics 203–206, 215–225
 - phase 73
 - γ phase 238
- nucleation curve 52

nucleation undercooling 404
 nucleus, (un)faceted 222–223
 number density profiles 152, 154
 numerical reliability, MD simulation
 166–167
 numerical simulation, *see* simulation

o

obstacle potential 330
 off-dendrite regions 416
 one-component systems, solidification
 354–361
 Onsager coefficient 125–126, 143–144, 147
 optimization, computational, *see*
 computational optimization
 order, short-range, *see* short-range order
 order parameter, phase-field 374
 “ordered” interfaces 89
 organic mixtures 34–35
 Ornstein–Zernicke form 147
 oscillating drop technique 59
 overheating 315
 oxide formation, Nd 252

p

P (phosphor)
 —Ni–P 118–119
 —Pd–Cu–Ni–P 118, 137–139
 packing, dense random 175–176
 packing fraction 174, 177
 pair interaction energy 186
 parabolic fronts, co-focal 317
 partial coordination numbers 178
 partial pair correlation functions 148–149
 partial structure factors 120–121, 143
 partial wetting 34
 particle motion, tagged 143
 partition coefficient, equilibrium 162
 pattern formation, dendritic 373
 Pb, Al–Pb 40–41
 —Al–Pb 89–90
 Pb nanoparticles 91–95
 Pd–Cu–Ni–P 118
 —demixing tendency 137–139
 pearls, string of, *see* string of pearls
 Peclet number 49, 317–318, 357
 —chemical diffusion 367
 Percus–Yevick approximation 121–123
 peritectic growth 215–225
 peritectic systems
 —melting in 312–316
 —microstructure evolution 245–261
 —PF modeling 220–223
 —phase diagrams 313

phase

—coexisting 100
 —hard magnetic, *see* hard magnetic
 phase
 —metastable A1 “phase” 283–287
 —soft magnetic, *see* soft magnetic phase
 Φ phase, *see* hard magnetic phase
 χ phase, metastable 227–240
 phase behavior, simulation 141–156
 phase diagram
 —arbitrary 325
 —azeotrope 196
 —binary eutectic 388
 —charge variable systems 193–196
 —charged sphere mixtures 196–199
 —eutectic 347
 —Ni–Fe 284
 —Ni–Zr 158, 161
 —Ni–Zr melts 161–162
 —peritectic materials 215
 —quasi-binary 228, 237
 —ternary monotectic 4–5
 —triple junction 312–315
 phase equilibria, nanoscale metals and alloys
 87–107
 phase-field (PF) equation, basic 373
 phase-field (PF) kinetics 355
 phase field (PF) modeling
 —and MD simulation 162–165,
 345–346
 —compositional stress 299–309
 —convective 330–336
 —dendrite growth 341–345
 —dissipative dynamics 322
 —eutectic growth 346–350
 —heterogeneous nucleation 220–223
 —hydrodynamic convection 217–220
 —input parameter 162–163
 —Karma corrections 374–375
 —multicomponent multiphase systems
 326–327, 373–376
 —peritectic alloys 220–223
 —solidification 339–351
 phase-field (PF) order parameter 374
 phase-field (PF) simulations
 —diffusion coefficients 403
 —Nd–Fe–B 215–225
 —nonisothermal 343
 phase-field (PF) vector 328
 phase formation, multicomponent monotectic
 Al-based alloys 3–17
 phase nucleation 73
 γ phase nucleation, interfacial energy 238
 phase rule, Gibbs’ 98

- phase selection in undercooled melts 227–244
- phase separation 408
 - temperature 26
- phase stability 88–105
- phase transitions 88–105
 - elastic effects 311–324
 - first-order 88
- planar crystallization front, Ni–Zr 162–165
- planar solidification front 44
- plastic deformation 258
- Poisson ratio 302
- polarization (magnetic), saturation 245
- polarized neutrons 265–268, 270
- polydispersity 185, 189
- polymorphic transition 313
- polystyrene 188
- polytetrahedral structure 166
- Porod law 268, 274–275
- potential
 - Coulomb 185
 - Debye–Hückel 186
 - diffusion 302
- precipitates, dendritic 415
- propagation
 - fast crack 319–323
 - planar crystallization front 163–165
- proeutectic phase 219, 234
 - microstructure evolution 245–246, 252, 257–259
- protecting atmosphere 58
- pseudoregular solutions 32
- pump effect, electromagnetic 249
- pure systems, solidification 354–361
- pyrometer 58
 - two-color 114, 256
- q**
- quartz tube 246
- quasi-binary phase diagram 228, 237
- quasi-crystals 414–418
- quasi-elastic neutron scattering 113–115, 150
- quaternary alloys
 - Al–Bi–Cu–Sn 11–15
 - invariant reactions 13
- quenching 75
 - as-quenched composite 410
- r**
- radial heat flow 74
- radiation, synchrotron, *see* synchrotron radiation
- radiogram
 - LC method 134–135
 - X-ray, *see* X-ray radiography
- random packing, dense 175–176
- rapid quenching 75, 89, 277–295
 - Nd–Fe 280–288
 - Nd–Ga–Fe 288–295
- rapid solidification 299
 - Ni–Al–Zr 376–378
 - solute trapping 345
 - ternary alloys 367–368
- rare-earth magnets 245
- Rayleigh instabilities 39, 45, 364
- Rayleigh speed 321
- reactions, chemical, *see* chemical reactions
- Redlich–Kister form 58
- Redlich–Kister/Muggianu-type extrapolation 12
- reduced gravity 360
- reflection, Bragg 91
 - Bragg 199
- relaxation time, inverse 116
- remanence 293
- renormalization theory 36
- Reynolds number 247–248, 357
- Reynolds transport theorem 330–331
- rhombohedral Ni–Fe 277
- rod-like structure, hexagonal 349
- room-temperature demagnetization curves 287–288
- rotation
 - crucible 247–248
 - forced, *see* forced rotation technique
- s**
- S-Voronoi tessellation 174
- SAED, *see* selected area electron diffraction
- samples, equilibration and preparation 75–76
- SANS, *see* small-angle neutron scattering
- saturation polarization 245
- scanning calorimetry (DSC), differential, *see* differential scanning calorimetry
- scattering
 - isotropic 266
 - neutrons, *see* neutron scattering
 - static light 190–193
 - ultra small-angle X-ray, *see* ultra small-angle X-ray scattering
- scattering law 114
- scattering length density (SLD), magnetic 272–273
- Scherrer constant 199
- screened Coulomb potential 185
- SDAS, *see* secondary dendritic arm spacing

- second law of thermodynamics 332–336
- secondary dendritic arm spacing (SDAS) 252–255, 259
- sedimentation, differential 198
- “seed” phase 221
- segregation, interfacial 98
- segregation coefficient 303–304
- Seidel smoothing operator, Gauss– 306–307
- Sekerka instability, Mullins– 301
- selected area electron diffraction (SAED) 285–287
- selection, spacing 379–381
- self-absorption 114
- self-diffusion, activation energy 120
- self-diffusion coefficient 116–118
- Arrhenius plot 137
 - mode coupling theory 124–125
- self-diffusivity 111
- self-dissociation, solvents 186
- self-lubricating bearings 19
- semi-grandcanonical ensemble (SGMC) 142, 145
- separation, phase 408
- SGMC, *see* semi-grandcanonical ensemble
- shadowgraphs 59
- sharp-interface model 325
- binary alloys 362–364
 - extended theory 240
 - one-component systems 354–356
 - ternary alloys 367–369
- shear cell experiment 139
- shear modulus 187–189, 194–196
- time evolution 198
- shear viscosity 150–151
- short-range order
- fcc 175–176
 - icosahedral 123, 175–176
 - liquid Zr–Ni 120–124
 - topological 121
- Si, interfacial tension 24
- signal-to-noise ratio, neutron scattering 113
- silanol groups 195
- silica aerogel 41–42
- silica suspensions, colloidal 191–192
- silver, *see* Ag
- simplex, Nelder–Mead 173
- Nelder–Mead 180
- simulation
- binary alloys 141–156
 - buoyancy-driven convection 379
 - compositional stress 306–308
 - fibrous binary eutectic growth 390
 - floating zone facility 250
 - forced rotation technique 247–248
 - MD, *see* molecular dynamics simulation
 - microscopic temperature field 77
 - Monte Carlo, *see* Monte Carlo simulations
 - nonisothermal PF 343
 - PF, *see* phase-field simulations
 - transient growth 402–403
 - univariant growth 390
 - Yukawa systems 187
- single-component colloidal melts, solidification 185–211
- single convection roll 251
- single-phase material, external interfaces 88–97
- single step crystallization 235
- singularity, critical 148
- SLD, *see* scattering length density
- small-angle neutron scattering (SANS) 265–268
- Zr–Ti–Nb–Cu–Ni–Be 409, 417–418
- smoothing operator, Gauss–Seidel 306–307
- Sn
- Al–Bi–Cu–Sn 11–15
 - In–Bi–Sn 395–400
 - interfacial tension 24
 - ternary alloys 6–8, 11
- soft magnetic phase 263–265
- Nd–Ga–Fe 291–292
 - Ni–Fe 277
- soft metals 19
- software, *see* algorithms and software
- solid-liquid interface energy
- concentration dependence 83–84
 - measurement 78–79
 - ternary alloys 73–86
- solid-liquid interfaces
- atomic attachment kinetics 111
 - molecular layers 215
 - morphological stability 299
- solid phase, diffusion 316
- solid solution 187
- ideal 197
- solidification
- colloidal melts 185–211
 - combined motion of fronts 316–318
 - compositional stresses 299–309
 - constitutional effects 362–366
 - dendritic, *see* dendrite growth, dendritic
- solidification
- diffusion-limited 369

- solidification (*contd.*)
 - directional, *see* directional solidification
 - multicomponent multiphase systems 339–351
 - planar front 44
 - pure (one-component) systems 354–361
 - rapid, *see* rapid solidification
 - ternary alloys 366–369
 - transient 401–402
 - Zr–Ti–Nb–Cu–Ni–Be 409
- solidification cells 299, 307
- solidification velocity 45–49
- solids, elemental 97
- solidus curve 52
- solvent boundary layer 343
- solute current 306
- solute trapping 300
 - binary alloys 363
 - rapid solidification 345
- solutions
 - ideal 61–62
 - pseudoregular 32
 - solid 187, 197
- solvents, self-dissociation 186
- spacing, stability diagram 381
- spacing selection, binary alloy 379–381
- spectra, X-ray 232
 - X-ray 236
- spectroscopy
 - atomic absorption 133
 - electron energy loss 89
- spheres
 - charged mixtures 196–199
 - hard 175–176
- spherical cap model 216
- spinning, melt 279
- stability
 - morphological 299
 - nanoscale systems 88–105
 - thermal 407
- stability diagram 46–47, 100
 - spacings 381
- stacking sequence 399
- static interface 163
- static light scattering, time-resolved 190–193
- stationary coupled growth 398–400
- stationary growth morphology 216
- stationary morphology formation 387–406
- stationary thermocouples 74
- stationary three-phase coupled growth 400
- stationary univariant growth 403–404
- statistical thermodynamics 30
- steady-state convection rolls 383
- steady-state regime 312–315
- stirring
 - electromagnetic 246
 - two-phase 250
- Stokes–Einstein relation 126
- Stokes equation, Navier–
 - Navier– 355
- Stokes motions 19
- strain, coherency 316
- straining, high-pressure torsion 92
- stream lines 249
- stress
 - compositional 299–309
 - surface 331
 - thermal 308
- stress–strain plots 258
- stress–strain relationship 302
- stress tensor 302, 331
- stretching, interface 300
- string of pearls 39–40, 44–47
 - transition from fibrous structures 48–50
- structural entropy 167–168
- structure factors
 - neutron scattering 207
 - total 120
- sum rule of Cummings and Blackburn 59
- supercooling, capillary 48
- superlattice reflex 233
- superlattice structure, intermetallic phases 240
- surface
 - diffusion 300
 - energy density 329
 - free-surface phenomena 247
 - liquidus 6–7
- surface charge density 195
- surface entropy density 340–341
- surface stress 331
- surface tension 57, 59
 - Gibbs energy 57
 - isothermal curves 66
 - multicomponent alloys 55–71
- susceptibility 143
- suspensions
 - charged colloidal 186–190
 - colloidal silica 191–192
- symmetric LJ mixture 144–148
- symmetry, fivefold 172
- synchrotron radiation 227–244
- synchrotron radiation imaging 380

- t**
- tagged particle motion 143
- Teflon tubing system 188
- temperature
- critical 151
 - Curie 251, 263
 - “eutectic” 104
 - liquidus 56
 - melting, *see* melting temperature
 - phase separation 26
- temperature dependence
- enthalpy 159
 - liquid-liquid interfacial tension 33
 - magnetization 264
- temperature field, microscopic 77
- temperature gradient, *see* “grain boundary groove in an applied temperature gradient” method
- temperature–time profiles 232–235
- tensioactivity 33
- tensiometry 21
- tension
- interfacial, *see* interfacial tension
 - surface, *see* surface tension
- ternary alloys
- Al-based 6–10
 - Al–Ni–Zr 165–168
 - buoyancy-driven fluid flow 381–383
 - liquidus surface 6–7
 - sharp-interface model 367–369
 - solid-liquid interface energy 73–86
 - solidification 366–369
- ternary eutectic alloys 349
- directional solidification 387–406
 - general aspects 388–389
- ternary eutectic point, invariant 389
- ternary interaction parameter 56, 62–64
- ternary miscibility gap 5–7
- ternary monotectic phase diagrams, systematic classification 4–5
- tessellation, Voronoi 174–175
- theory
- Brener 341, 359
 - classical nucleation, *see* classical nucleation theory
 - extended sharp interface 240
 - fast crack propagation 319–323
 - mode coupling 119, 124–125
 - renormalization 36
 - see also* laws and equations, model
- thermal activation, homogeneous nucleation 203
- thermal analysis, differential, *see* differential thermal analysis
- thermal analysis
- thermal conductivity 74, 81–82
- thermal expansion 56, 59
- multicomponent alloys 55–71
- thermal insulator 41
- thermal stability, BMGs 407
- thermal stress 308
- thermocouples, stationary 74
- thermodynamic assessment 391, 395–396
- thermodynamic extrapolation, binary data sets 11
- thermodynamic forces, influence on diffusion 135–139
- thermodynamic modeling, Calphad method 3
- thermodynamics
- crystallization 158–162
 - irreversible 332
 - multiphase melts 3–108
 - statistical 30
- thick-film solution 133
- Thompson–Freundlich-type equations, Gibbs– 98
- Thomson coefficient, Gibbs– 79–83
- Thomson equation, Gibbs– 78–79, 299–300, 340
- Thornton formalism, Bhatia– 120–122
- three-phase coupled growth, stationary 400
- Ti 119–120
- Zr–Ti–Nb–Cu–Ni–Be 407–420
- Ti–Al 245–261
- forced rotation experiments 256–258
- Tiller–Grinfeld instability, Asaro– 319
- Asaro– 321
- time of flight (TOF) spectrometer 113–116
- time-resolved static light scattering, instrumentation 190–193
- tin, *see* Sn
- tip curvature 321
- TOF, *see* time of flight
- topological contrast 290
- topological short-range order 121
- torsion straining, high-pressure 92
- total structure factors 120
- transient growth 400–404
- transient solidification 401–402
- transition metals, substitution 68
- transport coefficients 143–144
- transport processes, microscopic 141–156
- transport theorem, Reynolds 330–331
- trapping, solute 300
- solute 345
- triple junction, phase diagrams 312–315

- tubing system, Teflon 188
 tunable interactions, in charged colloidal suspensions 186–190
 two-color pyrometer 114, 256
 two-phase layer structure 161
 two-phase magnets 292
 “two-phase” nucleus 222
 two-phase stirrer 250
 two-phases model 169
- u**
- ultra small-angle X-ray scattering (USAXS) 186–190, 193–194, 206–208
 undercooled melts
 —binary 112
 —dendrite growth and grain refinement 353–372
 —isothermally 348
 —phase selection 227–244
 —structure 206–207
 undercooling
 —critical 361
 —kinetic 367
 —local 77–78
 —nucleation 404
 —velocity 343
 unafaceted nucleus 222–223
 univariant eutectic grooves 403
 univariant growth 390
 —stationary 403–404
 unsaturated magnetic systems 265–268
 USAXS, *see* ultra small-angle X-ray scattering
- v**
- vacuum, “elastic” 319
 varying convection 245–261
 Vegard’s law 56
 velocity
 —growth, *see* growth velocity
 —solidification, *see* solidification velocity
 velocity undercooling 343
 vibrating sample magnetometer (VSM) 251, 255, 280
 vibration entropy 159, 167
 viscosity, shear 150–151
 viscous dissipation 356
 Voronoi-like cell 43
 Voronoi tessellation 174–175
- w**
- Waller factor, Debye– 122
 water, milli-Q 190
 water cooled jacket 74
 wetting phenomena 33–36
 Wilhelmy plate method 21
 Wilson–Frenkel law, binary colloidal crystals 200–201
 Wilson–Frenkel model 142, 153
 Würth’s approximation 201
- x**
- X-ray diffraction (XRD) 279–282, 287–293
 —Zr–Ti–Nb–Cu–Ni–Be 408–409
 X-ray radiography
 —*in situ* 112
 —LC method 134–135
 X-ray scattering, ultra small-angle, *see* ultra small-angle X-ray scattering
 X-ray spectra 232
 —energy-dispersive 133
 —energy dispersive 236
- y**
- Yevick approximation, Percus– 121–123
 Young–Laplace equation of capillarity 21–23
 Young’s modulus 302
 Yukawa systems, simulation 187
- z**
- Zernicke form, Ornstein– 147
 Ziman formalism, Faber– 120–122
 Zn 6
 —Ag–Cu–Zn 391–395
 zone, floating, *see* floating zone facility
 Zr
 —Al–Ni alloys 367–369, 376–378
 —Al–Ni–Zr 165–168
 —Cu–Zr amorphous alloy 177–178
 —Ni–Zr 158–165, 343, 362–364
 Zr-based alloys, Zr–Ti–Nb–Cu–Ni–Be, *see* Zr–Ti–Nb–Cu–Ni–Be
 Zr–Nb–Cu–Ni–Al 408
 Zr–Ni 119–124
 Zr–Ti–Nb–Cu–Ni–Be 407–420
 —solidification 409
 Zr–Ti–Ni–Cu–Be 119–120
 —neutron scattering 113