

Index

A

- Abrasive wear theory, 380
- Absorption coefficient, 84–85, 167–171
- Activation energy, 97–98, 100
- Anionic and cationic vacancies
 - energy states, F^+ - and F^- -centers, 290, 291
 - Smacula formula, 292
 - Ti³⁺ ion doping, 293
 - V²⁺ and V⁻ centers, optical absorption, 292
- Annealing effect
 - crystal strength
 - breakdown probability, 435
 - characteristics, 434
 - mechanical strength, 435–436
 - high temperature annealing
 - crystal structure, 416
 - machined surfaces, light transmittance, 442–443
 - microfractures, 414–415
 - shear deformation, 415–416
 - stress distribution, 415
 - laser characteristics, 430–431
 - loading
 - cleaving stress, 444
 - diffusive dissolution, 443–444
 - mechanical properties, 427
 - neutral medium, 419
 - optical inhomogeneity
 - crystallization front shapes, 436–437
 - refractive index, 438, 439
 - optical properties, 427–430
 - oxidizing annealing, 419–420
 - point defect, diffusion and interaction, 422–426
 - redox potential, 417–419
 - reducing atmosphere, 420–422
 - small-angle scattering (SAS)
 - color center crystal, 442
 - premelting temperature, 440

- refractive index, inhomogeneity, 440–441

- structural defects, 441
- stress relaxation, 431–433

- Antireflection coating external transmission, 86, 87

B

- Bar code scanning, 470
- Bending strength, 95
- Bravais classification, 55
- Bridgman–Stockbarger method. *See* Directed crystallization methods

C

- Capillary action-shaping technique (CAST), 267
- Cathodoluminescence spectrum, 90
- Cellular crystallization front-skeletal growth transition, 355
- Chemical–mechanical treatment
 - defective layer control
 - abrasive wear theory, 380
 - chemical polishing, 389
 - fixed-abrasive treatment, 381–384
 - free abrasive treatment, 384–387
 - gas polishing, 390
 - lubricating-cooling liquid, 387–389
 - polishing parameters, 390
 - surface grindability, 380–381
 - grinding
 - elastic grinding, 364
 - hard grinding, 363–364
 - submicrocracks, 364–365
 - surface damage, 364
 - lapping, 365
 - layer depth and grain size, 377–378

- Chemical-mechanical treatment (*cont.*)
- mechanically treated sapphire structure
 - abrasive dispersion, brittle materials, 375–376
 - electron diffraction analysis, 376–377
 - interference function method, 376
 - quasiamorphous layer, 378
 - surface-adjacent layer damage, 374
 - surface structure, fractal model, 374–375
 - microindentation, sapphire strength prediction
 - activation energy, 392
 - deformation characteristics, 390–391
 - deformation temperature, 393
 - dislocation configuration, 391
 - dislocation length, 391–392
 - fracture toughness coefficient, 395–396
 - impurity effect, 394–395
 - plasticity parameter, 393–394
 - polishing
 - article cost and surface quality, 373–374
 - colloidal silica polishing, 371, 372
 - dry chemical-mechanical polishing, 370–371
 - elastic emission machining (EEM), 371–372
 - mechanical polishing, 368
 - treatment efficiency, 372
 - vs. lapping, 365–366
 - wet chemical-mechanical polishing, 368–370
- Color center (CC) laser, 30
- Compliance, 172
- Compression modulus, 96
- Compression strength, 95
- Contact zone melting, single-piece joints
 - crystallization, 463
 - crystallization front, 464–465
 - joint quality, 466
 - transmission spectra, 465
 - welding apparatus, 464
- Corrosion resistance
 - anionic nonstoichiometry, 148
 - dislocation density, 149
 - dissolved layer thickness, 148, 149
 - erosion resistance, 147, 148
 - Kyropoulos method, 149
 - surface energy, 150
 - tungsten, interaction
 - chemical adsorptive action, 153
 - dissociative evaporation, 152
 - interaction energy, 153
 - isobar-isothermal potential, 151
 - kinetics, 152
 - migration and desorption, reaction product, 153
 - rate constant, 151
- Corundum motive, 56, 59, 60
- Crystal growth methods
 - gaseous phase
 - adsorption layer, 190–191
 - aluminum chloride monomer, 193
 - cathode sputtering and deposition, 189
 - chemical reaction method, 190
 - growth rate, 194
 - sublimation method, 190
 - supersaturation, 191
 - vapor-liquid-crystal (VLC)
 - mechanism, 194–196
 - whisker growth, 191–193
 - melt phase
 - capillary channel, 262–267
 - CAST, 267
 - cold crucible/skull method, 245–247
 - container materials, 237–239
 - crystal displacement, 270–271
 - Czochralski method, 243–245
 - dimension and shape definition, 257
 - EFG, 267
 - floating crucible method, 245
 - gaseous atmosphere, 252–255
 - horizontal directed crystallization, 249–252
 - hybrid method, 267
 - impurity distribution, 209–210
 - installation schemes, 248, 249
 - inverted Stepanov technique, 267
 - Kyropoulos method, 239–241
 - local shape-making method, 267–269
 - micropulling-down (μ -PD)
 - method, 267
 - modified Verneuil methods, 233–234
 - noncapillary shaping method (NCS), 274–276
 - one-/two-component systems, 209
 - physical and chemical processes, 211
 - profile surface, 271–274
 - resistance heaters, 248, 250
 - shape formation, 257–262
 - temperature gradient direction, 210–211
 - tubular crystal manufacturing
 - scheme, 256
 - variational shape-making, 269–270
 - zone melting methods, 234–237
 - solid-phase
 - arbitrary boundary, 279–280

- conjugated high-mobility boundaries, 280
- curvature formation, 277
- displacement scheme, 276
- pure undoped crystals, 282–283
- recrystallization, 280–281
- sintering process, 282
- small-angle tilted boundary, 279, 280
- surface-adjacent layer, 281
- surface energy, 278
- surface tension, 277–278
- transition region, 278, 280
- twist and slope boundary, 278, 279
- solution phase
 - equipment, hydrothermal method, 203–206
 - flux method, 206–207
 - hydrothermal method, 199–202
 - impurity distribution, 207–208
 - metastable phase method, 203
 - supersaturation, 196
 - temperature dependence, 196–198
 - temperature gradient method, 202–203
 - temperature reduction method, 203
 - temperature solubility coefficient, 198
- Crystal lattice deformation, 100, 101
- Crystallization front (CF), 302, 303
- Crystal morphology
 - crystallization front, 78–80
 - decantation surface, 78, 80
 - rhombohedron vertices, 78–80
 - definition, 73
 - equilibrium forms, 76–78
 - lattice relaxation, 73
 - lowest index surface energy, 74
- Crystal structure
 - Bravais classification, 55
 - corundum motive, 56, 59, 60
 - electronic energy structure, 65–66
 - ionic bond energy, 64–65
 - lattice parameters, 61
 - lattice state, vacancy influence
 - oscillation spectra, 62, 63
 - phonon state density, 62–64
 - point structure defect, 63
 - morphological and structural rhombohedral elementary cells, 57–59
 - nine cleavage planes, 67
 - periodic bond chains (PBC), 71–72
 - three active slip systems
 - Schmid-factor, 69
 - shearing stress, 68, 69
 - twinning, 69–71
- Cumulative failure probability, 97, 98
- Czochralski method, 243–245, 326
- D**
 - Defective layer control
 - abrasive wear theory, 380
 - chemical polishing, 389
 - fixed-abrasive treatment, 381–384
 - free abrasive treatment, 384–387
 - gas polishing, 390
 - lubricating-cooling liquid, 387–389
 - polishing parameters, 390
 - surface grindability, 380–381
 - Dielectric constant, 116, 117
 - Dielectric loss angle tangent, 117–119
 - Diffusion coefficient, 113–114
 - Diffusion welding, single-piece joints
 - intensification
 - brittle intermetallide layers, 455–456
 - physical contact and stretching force, 455
 - welding parameters, 454–455
 - interlayers
 - applications, 458
 - disadvantage, 459
 - mechanism
 - active center formation, 452–453
 - bulk interaction, 453
 - deformation, 453–454
 - physical contact, 452
 - surface contact, 451–452
 - technique, 461–463
 - welded seam structure
 - cracking resistance, 457–458
 - joint quality, 456
 - surface-adjacent crystal layers, 456–457
 - Directed crystallization methods
 - capillary channel, 262–267
 - CAST, 267
 - crystal displacement, 270–271
 - dimension and shape definition, 257
 - EFG, 267
 - gaseous atmosphere, 252–255
 - horizontal directed crystallization, 249–252
 - hybrid method, 267
 - installation schemes, 248, 249
 - inverted Stepanov technique, 267
 - local shape-making method, 267–269
 - micropulling-down (μ -PD) method, 267
 - noncapillary shaping method (NCS), 274–276
 - profile surface, 271–274
 - resistance heaters, 248, 250
 - shape formation, 257–262
 - Stepanov method

Directed crystallization methods (*cont.*)

- capillary channel, 262–267
- CAST and EFG, 267
- crystal displacement, 270–271
- dimension and shape definition, 257
- inverted Stepanov technique, 267
- local shape-making method, 267–269
- micropulling-down (μ -PD)
 - method, 267
- noncapillary shaping method (NCS), 274–276
- profile surface, 271–274
- shape formation, 257–262
- tubular crystal manufacturing
 - scheme, 256
 - variational shape-making, 269–270
- tubular crystal manufacturing scheme, 256
- variational shape-making, 269–270

Dissolution

- anisotropy, 136
- G and L forms, 130, 131
- KF and K_2CO_3 , 133
- $K_2S_2O_7$, 132
- NaOH water solutions, 135–137
- NH_4F solution, 136
- orthophosphoric acid, 137–139
- PbO – PbF_2 , 132
- polar diagram, 133, 134, 136
- pure PbF_2 , 132
- rate constant, 135
- stages, 129, 130
- stereographic projections, 135
- vertex motion rate, 129
- V_2O_3 , 133

Dynamic strength

- brittle failure, 105, 106
- chip-off, 105–107
- deformation relief, 107, 108
- destruction, 102
- relative strength and cracking resistance, 104, 105
- shock testing, 103, 104
- shockwave loading, 100, 101
- surface quality, 104, 105

E

- Edge-defined film-fed growth (EFG), 267
- Elastic constant, 95, 171
- Elastic emission machining (EEM), 371–372
- Elastic grinding, 364
- Electrical properties
 - dielectric constant, 116, 117
 - dielectric loss angle tangent, 117–119

- electric conduction, 114–117
- magnetic susceptibility, 119
- resistivity, 115, 116

Electric conduction, 114–117

Electronic energy structure, 65–66

Electron irradiation, 185–186

Emittance, 88–89

Engineering applications

- abrasive, 12–13
- ball lenses and CD disks, 13
- capillaries and fibers, 12
- chemical ware, 11
- constructional sapphire elements, 8
- cutters
 - sharpening angles, 46
 - vs. hard-alloy analogs, 8
- devices
 - corundum bearings and bushes, 44
 - sapphire pivots, 7
- dispersionally hardened composites, 13
- nitride-sapphire system, 10–11
- sapphire substrates
 - basal and additional planes, 8–9
 - bicrystalline substrates, 10
 - carbon nanotubes, 11
- Si film, heteroepitaxy, 8–10
- watch industry, 6–7
- wear-resistant sapphire elements, 7–8

Enthalpy, 175

Erosion resistance, 147, 148

F

- Frenkel defects, 289
- Friction coefficient, 95, 96

G

Gnomonic projection, corundum, 71, 159

Grain structure

- Cr^{3+} concentration, 330, 331
- diffusion flows, 332–333
- dislocation density, 329
- Kosselev principle, 331
- point defects distribution, 326, 331
- quality analysis and solid-phase method, 333
- spatial orientation, 330
- Stepanov and Verneuil methods, 329, 330
- thermodynamic parameters, 329

Grinding

- elastic grinding, 364
- hard grinding, 363–364
- submicrocracks, 364–365
- surface damage, 364

H

- Hammer-driven mesh feeders, 229
- Hard grinding, 363–364
- HDS method, 251, 252
- HDS method, density distribution, 299
- Heat-exchange method (HEM)
 - automated control, 247–248
 - cold crucible/skull method, 245–247
 - Czochralski method, 243–245
 - drawback, 243
 - floating crucible method, 245
 - growth stages, 241, 242
 - temperature gradients, 242–243
- High-temperature crystallization, 469

I

- Interplanar distance, 61, 157–158
- Inverted/modified Kyropoulos method.
 - See* Heat-exchange method
- Ionic bond energy, 64–65
- Ionic plasma etching, 145
- Irradiation embrittlement, 178–179
- IR reflection spectra, 183–185

J

- Jewelry industry
 - color ennoblement, 4–5
 - crystal color change
 - irradiation and implantation, 5
 - thermochemical treatment, 5–6

K

- Knoop hardness, 95
- Kyropoulos method, 239–241, 335

L

- Langmuir evaporation rate, 146
- Laser properties
 - activator distribution coefficient, 119, 120
 - Cr:Al₂O₃ and Ti:Al₂O₃, 120
 - optical strength, 120–122
 - radiation resistance, ruby, 122–125
- Lattice parameters, 61
- Linear expansion coefficient, 109–110, 172
- Low dislocation block-free crystals, 310
- Luminescence
 - anionic and cationic nonstoichiometry, 92–93
 - cathodoluminescence spectrum, 90
 - centers, spectral and kinetic characteristics, 93

- chromium and titanium, 90
- energy level scheme, 91
- thermally stimulated luminescence, 90, 91
- thermoluminescence spectrum, 94

Luminophor screens, 21

M

- Magnetic plasma etching, 145
- Magnetic susceptibility, 119
- Mechanical characteristics
 - activation energies and activation bulk, 97–98, 100
 - bending strength, 95
 - compression modulus, 96
 - compression strength and density, 95
 - elastic constants, 95, 171
 - friction coefficient, 95, 96
 - hardness, 95
 - Poisson coefficient, 97
 - rupture and shear modulus, 96
 - tensile strength, 95
 - Weibull modulus, 96–97
 - Young's modulus, 96
- Medical applications
 - medical equipment, 42
 - microsurgery
 - blade sharpness, 38
 - scalpels, 38–41, 54
 - sapphire implants (SIs), 35
 - biochemical and biomechanical testing, 32–33
 - dentistry, 34, 36
 - friction pairs, 37–38
 - functional merits, 33
 - immunologic disturbances, 33–34
 - maxillofacial implants, 53
 - nickel and chromium, 34
 - osseointegration, 33
 - thread-type implants, 36
 - vertebra endoprosthesis, 34, 36
- Melt crystal growth method
 - container materials
 - iridium, 238
 - molybdenum, 238–239
 - performance properties, 237
 - rhenium, 239
 - tungsten, 238
 - W–Re, Mo–Re and W–Mo alloys, 239
 - directed crystallization methods
 - capillary channel, 262–267
 - CAST, 267
 - crystal displacement, 270–271
 - dimension and shape definition, 257

- Melt crystal growth method (*cont.*)
- EFG, 267
 - gaseous atmosphere, 252–255
 - horizontal directed crystallization, 249–252
 - hybrid method, 267
 - installation schemes, 248, 249
 - inverted Stepanov technique, 267
 - local shape-making method, 267–269
 - micropulling-down (μ -PD) method, 267
 - noncapillary shaping method (NCS), 274–276
 - profile surface, 271–274
 - resistance heaters, 248, 250
 - shape formation, 257–262
 - tubular crystal manufacturing scheme, 256
 - variational shape-making, 269–270
- heat-exchange method (HEM)
- automated control, 247–248
 - cold crucible/skull method, 245–247
 - Czochralski method, 243–245
 - drawback, 243
 - floating crucible method, 245
 - growth stages, 241, 242
 - temperature gradients, 242–243
- impurity distribution, 209–210
- Kyropoulos method, 239–241
- modified Verneuil methods, 233–234
- one-/two-component systems, 209
- physical and chemical processes, 211
- properties
- density, 213
 - diffusion, 215–216
 - electric conductivity, 214–215
 - evaporation, 221–222
 - heat conductivity, 216
 - heat transfer, 220–221
 - material interaction, 218–220
 - melting and crystallization temperature, 212–213, 287
 - optical properties, 213
 - specific conductivity, 288
 - surface tension, 213
 - thermal dissociation, 216–217
 - vapor pressure, 288
 - viscosity, 213–214, 288
- temperature gradient direction, 210–211
- Verneuil method
- advantages and drawback, 227
 - burner, 227–229
 - crystal diameter, 225
 - crystal size, 226
 - feeder, 229–231
 - industrial air separator, 225, 226
 - industrial production, 223–224
 - muffle, 230, 232–233
 - redesigned rubies, 223
 - Verneuil growth unit, 224, 225
- zone melting methods
- cylindrical crystal preparation, 235
 - electron-beam melting, 236–237
 - horizontal and vertical zone melting, 234, 235
 - material purification, 234
 - zone stability calculation, 236
- Microindentation, sapphire strength prediction
- activation energy, 392
 - deformation characteristics, 390–391
 - deformation temperature, 393
 - dislocation configuration, 391
 - dislocation length, 391–392
 - fracture toughness coefficient, 395–396
 - impurity effect, 394–395
 - plasticity parameter, 393–394
- Mohs' hardness, 95
- Molar heat capacity, 112–113
- Molecular beam method, 190
- N**
- Neutron irradiation
- intensity dose dependence, 182–183
 - IR reflection spectrum, 180–182
 - kinetics, 183
 - optical and structural characteristics, 182
- Nitride-sapphire system, 10–11
- Noncapillary shaping method (NCS), 274–276
- O**
- Optical inhomogeneity, annealing effect
- crystallization front shapes, 436–437
 - refractive index, 438, 439
- Optical properties
- absorption coefficient, 84–85, 167–171
 - emittance, 88–89
 - luminescence
 - anionic and cationic nonstoichiometry, 92–93
 - cathodoluminescence spectrum, 90
 - centers, spectral and kinetic characteristics, 93
 - chromium and titanium, 90
 - energy level scheme, 91

- thermally stimulated luminescence, 90, 91
- thermoluminescence spectrum, 94
- reflection coefficient, 83–84
- refraction
 - refractive index, 80–83
 - thermo-optical coefficient, 82, 83
- scattering, 86
- transmission, 85–87
- Optical strength, 120–122
- Optics
 - $\text{Al}_2\text{O}_3:\text{Cr}^{3+}$ -based luminescent pressure transducers, 24–25
 - focusing cones, 15–16
 - laser elements
 - color center (CC) laser, 30
 - passive sapphire gates, 30–31
 - ruby lasers, 26–27
 - titanium-doped sapphire, 27–30
 - lenses and prisms, 14
 - light guides and optical fibers, 14–15
 - luminophor screens, 21
 - ruby-based masers and phasers, 31
 - ruby-based pressure transducers, 25–26
 - scintillators, 17–21
 - sodium high-pressure lamps, sapphire shells, 16–17
 - thermocouple casings and meniscuses, 16
 - thermoluminescent detectors (TLDs)
 - advantages, 21
 - crystal growth, 22
 - deep traps, 24
 - thermal treatment and anion-defective sapphire, 23
 - windows, 13–14
 - flange, 47
 - wedge, 49
 - X-ray interferometers and monochromators, 17
- P**
 - Periodic bond chains (PBC), 71–72
 - Phase interface morphology, 354–355
 - Phonon state density, 62–64
 - Plastic deformation, thermoelastic stress
 - block boundary formation, 305, 306
 - cross section, 306–308
 - crystallization front (CF), 302, 303
 - density distribution, 304, 305
 - plastic flow, 301, 302
 - radial temperature gradients, 303
 - residual stress, 302–303
 - stress distribution, 300, 301
 - temperature field nonlinearity, 300
 - Point defect distribution, 379
 - Poisson coefficient, 97
 - Polishing
 - article cost and surface quality, 373–374
 - colloidal silica polishing, 371, 372
 - dry chemical–mechanical polishing, 370–371
 - elastic emission machining (EEM), 371–372
 - mechanical polishing, 368
 - treatment efficiency, 372
 - vs. lapping, 365–366
 - wet chemical–mechanical polishing, 368–370
 - Proton irradiation, 185
- R**
 - Radiation effects
 - bulk changes
 - annealing, radiation defect, 187
 - Cr ion, irradiation, 185
 - dislocation loops and vacancy complexes, 186
 - electron irradiation, 185–186
 - electrorestriction, 187
 - hardness, 185
 - ruby radiation resistance, 187–188
 - surface-adjacent layer, 180
 - thermal conductivity and transparency, 186
 - interstitial and vacancy clusters, 177
 - irradiation embrittlement, 178–179
 - mixed defect cluster, 178
 - physical effects, 179
 - surface changes
 - amorphous sapphire surface, 179
 - blister, 180
 - composition, 179–180
 - hygroscopicity, 180
 - IR reflection spectra, 183–185
 - neutron irradiation, 180–183
 - roughness, 179
 - structure and desorption, 180
 - vacancy pores, 177, 178
 - Radiation resistance, 122–125
 - Rebinder effect, 127
 - Reflection coefficient, 83–84
 - Refraction
 - refractive index, 80–83
 - thermo-optical coefficient, 82, 83
 - Resistivity, 115, 116
 - Ruby-based pressure transducers, 25–26

Ruby lasers, 26–27
Rupture modulus, 96

S

Sapphire implants (SIs), 35
 biochemical and biomechanical testing, 32–33
 dentistry, 34, 36
 friction pairs, 37–38
 functional merits, 33
 immunologic disturbances, 33–34
 maxillofacial implants, 53
 nickel and chromium, 34
 osseointegration, 33
 thread-type implants, 36
 vertebra endoprosthesis, 34, 36

Scintillators
 advantages and radiation stability, 18
 crystal dimensions, 19–21
 detector, 20–21
 pulse amplitude spectra, 19, 20
 spectrometric characteristics, 18–19

Shear modulus, 96

Shockwave damping, 102

Shockwave loading, 100, 101

Single-piece joint creation
 contact zone melting
 crystallization, 463
 crystallization front, 464–465
 joint quality, 466
 transmission spectra, 465
 welding apparatus, 464
 diffusion welding
 intensification, 454–456
 interlayers, 458–459
 mechanism, 452–454
 surface contact, 451–452
 welded seam structure, 456–458
 gluing, 448
 soldering
 capillary soldering, 449
 contact-reactive soldering, 449–450
 joint strength, 448–449
 vs. welding, 450

Small-angle scattering (SAS)
 color center crystal, 442
 premelting temperature, 440
 refractive index, inhomogeneity, 440–441
 structural defects, 441

Soldering, single-piece joints
 capillary soldering, 449
 contact-reactive soldering, 449–450
 joint strength, 448–449
 vs. welding, 450

Sound absorption, 174

Specific heat, 112, 113

Stefan–Boltzmann constant, 314

Stepanov method, 309, 310
 capillary channel
 chamber atmosphere, 265–266
 concave crystallization front, 266
 die surface, 262, 263
 Laplace pressure, 262, 264
 tungsten rods, 264–265

CAST, 267

crystal displacement, 270–271

crystal structure quality and mechanism, 338

dimension and shape definition, 257

EFG, 267

grain structure, 329, 330

hybrid method, 267

inverted Stepanov technique, 267

local shape-making method, 267–269

micropulling-down (μ -PD) method, 267

noncapillary shaping method (NCS), 274–276

profile surface
 economical characteristics, 272–273
 ribbon orientation, 271–272
 transmission, 273, 274

shape formation
 growth angle, 259
 heating power, 260, 261
 Laplace equation, 257–258
 meniscus height, 258–259
 negative and positive α_c (contact angle) values, 257–258
 radiation propagation, 261, 262
 realization schemes, 262, 263
 stability, 260–261
 tubular crystal manufacturing scheme, 256
 variational shape-making, 269–270

Structure defect formation, crystal growth
 anionic and cationic vacancies
 energy states, $F^{\cdot-}$ and F -centers, 290, 291
 Smacula formula, 292
 Ti³⁺ ion doping, 293
 V²⁺ and V[•] centers, optical absorption, 292
 Verneuil technique, 290, 292

block structure
 analysis, 317
 Burgers vector, basal dislocations, 320
 critical density, 319
 inherited block boundaries, 317–318
 polygonization, 318

correlation, structure quality and mechanism
 axial temperature gradient/growth rate ratio, 336, 337

- crystallization method, 334
 - experimental modeling, 335, 336
 - fracture toughness coefficient, 338, 340
 - interatomic collisions, 334
 - material aggregation process, 335
 - melt overheating, recrystallized zone, 341, 342
 - monocrystallization, 336
 - thin tungsten wire form, 339
 - Verneuil and Stepanov methods, 338
 - crystallization process, 315
 - dislocation formation, faceted pore, 315, 316
 - equilibrium concentration, point defects, 289, 290
 - grain structure
 - Cr^{3+} concentration, 330, 331
 - density of dislocation, 329
 - diffusion flows, 332–333
 - Kosselev principle, 331
 - point defects distribution, 326, 331
 - quality analysis, 333
 - solid-phase method, 333
 - spatial orientation, 330
 - Stepanov and Verneuil methods, 329, 330
 - thermodynamic parameters, 329
 - impurities effect, dislocation structure, 310–313
 - impurity, nonuniformity
 - Czochralski method, 326
 - heat transfer, 322
 - impurity inclusions, 322, 324
 - macrostriation, 322, 323
 - microstriation, 322–324
 - temperature distribution, 327, 328
 - ultramicrostriation, 326, 327
 - inclusion
 - Al_2O_3 – Al_4C_3 phase diagram, 358, 359
 - alumina decomposition, 343, 344
 - Barton, Prim, and Stichler formula, 345
 - container material, 346
 - crystallography, 354–357
 - F centers concentration, 351, 352
 - four-channel feeding, 347
 - impurity segregation, 344
 - large bubble growth stage, 351
 - maximal concentration supersaturation, 348, 349
 - microinclusion, ruby, 359
 - microparticle cutting, 353, 354
 - oversaturation, 345
 - pore composition, 343
 - pore formation, 346, 351
 - pore shapes, 344
 - small particle fusion, 353, 354
 - surface-adjacent defective layer, 349, 350
 - Verneuil technique, 346–347
 - Zhukovsky forces, 348
 - incoherent coalescence, dendrites, nuclei branches, 313
 - inherited dislocations
 - coefficients determination, cylindrical crystal, 296
 - density variation method, 298
 - dimensionless length functions, 297
 - HDS method, density distribution, 299
 - plastic deformation zone, 295–297
 - spatial orientation method, 298
 - structure control method, 297–298
 - interstitial ions
 - charge exchange process, 293
 - F_{Mg} center, 294
 - isovalent impurities, 294
 - ionic crystals, stoichiometric composition, 289
 - ions, foreign site, 295
 - plastic deformation, thermoelastic stress
 - block boundary formation, 305, 306
 - cross section, 306–308
 - crystallization front (CF), 302, 303
 - density distribution, 304, 305
 - plastic flow, 301, 302
 - radial temperature gradients, 303
 - residual stress, 302–303
 - stress distribution, 300, 301
 - temperature field nonlinearity, 300
 - Stefan–Boltzmann constant, 314
 - thermal regimen stability, 315, 316
 - vacancy mechanism, dislocation formation, 308–310
 - Submicrocracks, 364–365
- T**
- Tensile strength, 95
 - Thermal conductivity coefficient, 110–112
 - Thermal properties
 - boiling temperature, 109
 - diffusion coefficient, 113–114
 - ion implantation, 114
 - linear expansion coefficient, 109–110, 172
 - melting temperature, 109
 - molar heat capacity, 112–113
 - specific heat, 112, 113
 - thermal conductivity coefficient, 110–112
 - Thermal resistance, 110, 112

Thermal treatment, single crystal articles

annealing effect

crystal strength, 434–436

loading, 443–444

mechanical properties, 427

neutral medium, 419

optical inhomogeneity, 436–440

optical properties, 427–430

oxidizing annealing, 419–420

point defect, diffusion and interaction,
422–426

redox potential, 417–419

reducing atmosphere, 420–422

small-angle scattering (SAS),
440–442

stress relaxation, 431–433

disadvantages, 414

dislocation-free zone formation

concentration and density, 412–413

diffusion coefficient constancy, 413

obliteration effect, 411–412

vacancies, diffusion coefficient, 414

dislocations and block structure

ruby and chromium impurity, 403

scattering, 401–403

time dependences, 400–401

volume and temperature effect, 400

high-temperature annealing

crystal structure, 416

machined surfaces, light transmittance,
442–443

microfractures, 414–415

shear deformation, 415–416

stress distribution, 415

impurity striation evolution

impurity concentration, 404

impurity distribution, 405–406

optical density, ruby, 403–404

ultramicrostriation, 404–405

vacancy centers, 446

Verneuil method, 399

volume vs. subsurface layer, dislocation

annealing, mechanical treatment,
408, 409

birefringence and depth, 408–409

density and depth, 409

etched surface, 408

high-temperature annealing, 410

structural defects, 406–407

temperature dependence, 407

vacuum annealing, 411

Thermochemical polishing

alkali metal metavanadates, 142

evaporation forms, 146

hydrogen medium, 142–145

ionic and magnetic plasma etching, 145

potassium bisulfate melt, 141

SiO₂ colloidal solution, 142

solvent and regimen, 141

surface-adjacent layer removal, 142

Thermoluminescence spectrum, 94

Thermoluminescent detectors (TLDs)

advantages, 21

crystal growth, 22

deep traps, 24

TDL-500k sapphire detector, 49

thermal treatment and anion-defective
sapphire, 23

Thermo-optical coefficient, 82, 83

Ti-sapphire, 355–357

Titanium-doped sapphire

Al₂O₃:Ti³⁺ crystal, 27–28

amplifiers, 28

figure of merit (FOM), 28–29

tunable lasers, 29–30

Transmission, 85–87

V

Vacancy centers, 446

Vacancy mechanism, dislocation formation,
308–310

Verneuil method, 150

advantages and drawback, 227

anionic and cationic vacancies, 290, 292

burner, 227–229

crystal diameter, 225

crystal size, 226

crystal structure quality and
mechanism, 338

feeder, 229–231

grain structure, 329, 330

inclusion, 346–347

industrial air separator, 225, 226

industrial production, 223–224

muffle, 230, 232–233

redesigned rubies, 223

Verneuil growth unit, 224, 225

Verneuil technique, 290, 292

W

Wear-resistant sapphire elements, 7–8

Weibull modulus, 96–97

Welding, single-piece joints

contact zone melting

crystallization, 463

crystallization front, 464–465

- joint quality, 466
- transmission spectra, 465
- welding apparatus, 464
- diffusion welding
 - intensification, 454–456
 - interlayers, 458–459
 - mechanism, 452–454
 - surface contact, 451–452
 - technique, 461–463
 - welded seam structure, 456–458
- solid contact model, 450–451
- Wettability
 - physicochemical process, 127
 - surface-free energy (SFE), 125
 - wetting angle, 125–127
- Wetting angle, 125–127
- Wulff-Bragg's angle, 76, 163
- X**
- X-ray interferometers and
 - monochromators, 17
- Y**
- Young's modulus, 96
- Z**
- Zone melting methods
 - cylindrical crystal preparation, 235
 - electron-beam melting, 236–237
 - horizontal and vertical zone melting,
 - 234, 235
 - material purification, 234
 - zone stability calculation, 236