

## Index

### **a**

aberrations 7–9  
 abrasive cutting 16  
 absorbance 303  
 absorption contrast 96  
 absorption edge 50–51  
 acceleration voltage and probe current  
   144–145  
 achromatic lens 14  
 adatom 168–169  
 adhesive clamping 18  
 analyzer 33, 36  
 angular position of detector. *See* take-off  
   angle  
 angular quantum number 193  
 anti-Stokes scattering 289  
 aperture diaphragm 11–12  
 aperture size 141–143  
 apochromatic lens 14  
 astigmatism 8, 145  
 asymmetric stretching mode  
   290, 294  
 atomic force microscope (AFM) 163, 165,  
   180–182  
   – dynamic noncontact mode applications  
     181–183  
   – force modulation applications 182  
   – force sensors 172–174  
   – near-field forces 170–172  
   – operational modes 174–180  
   – static mode applications 180–181  
   – tapping mode applications 182  
 atomic number factor 216  
 atomic scattering factor 60  
 Auger electron 192, 194  
 Auger electron spectroscopy (AES)  
   221–225, 233–235, 239–241, 243–244,  
   246–247

### **b**

background noise 133–134  
 background spectrum 302  
 backscatter coefficient 139–140  
 backscattered electrons (BSEs) 129–130,  
   135, 137, 139–140, 216  
 barrier filter 38  
 baseline method, for absorbance  
   determination 329  
 beam brightness 131  
 Beer's Law 329–330  
 bending contours 120–122  
 bending modes 290–291  
 birefringence 31  
 body-centered cubic (BCC) structure 111  
 borax fusion 207  
 Bragg angle 68, 69, 76  
 Bragg's law 52–53, 69, 76, 96, 107, 118–119,  
   199–201, 313, 314  
 Bragg-Brentano arrangement 63–64  
 bright-field imaging 98–100  
 bright-field imaging 26–28  
 brightness 5

### **c**

Cahn microbalance 354–355  
 calibration 239  
 camera constant 107  
 camera length 107  
 cantilever force 176  
 capillary forces 172  
 Cassegrain lens 307  
 cationization 271  
 characteristic X-rays 48–51, 191–193, 204  
   – comparisons 194–196  
   – selection rules 193–194  
 charge neutralization 241  
 charged-coupled device (CCD) 153, 314

- chemical shift 235, 239–241
  - chromatic aberration 7
  - cold crystallization 341
  - cold field emission gun 86–87
  - cold mounting 18–19
  - collector lens 10
  - collision cascade 254, 257
  - collision sputtering 254
  - color temperature 9
  - colored filters 13
  - composition determination, with Raman spectroscopy 319–321
  - compositional contrast 139–141
  - compositional depth profiling 247–249
  - concentric hemispherical analyzer (CHA) 229–230, 233
  - condenser annulus 29
  - condenser lens 10, 39, 128
  - conductive film coating 148
  - confocal diaphragms 312
  - confocal laser scan microscopy (CLSM) 39
    - three-dimensional images 41–43
    - working principles 1–40
  - conjugate aperture planes 11
  - conjugate field planes 11
  - conjugate focal planes 11
  - constant analyzer energy (CAE) 229
  - constant retarding ratio (CRR) 229–230, 233
  - constant-current mode 168
  - constant-height mode 168
  - contact and noncontact modes 174–175
  - continuous X-rays 48
  - contrast 6, 94–95
    - formation 135
    - – compositional contrast 139–141
    - – electron- specimen interactions 135–137
    - – topographic contrast 137–139
    - phase contrast 15, 26–27, 29–31, 101, 103–106, 125
    - – theoretical aspects 102
    - – two- beam and multiple-beam imaging 105
  - convergence angle of probe 131
  - creep deformation 186
  - critical angle 206
  - critical-point drying 149–150
  - crossed position 33, 36
  - crystal defect images 117
    - bending contours 120–122
    - dislocations 122–124
    - wedge fringe 117–120
  - crystallographic contrast 141
  - crystallographic orientation determination
    - with Raman spectroscopy, 322–323
  - Curie point 358–359
  - curvature of field 8–9
- d**
- d-spacing 71, 76–77, 113, 200
  - damaged surface area 255
  - dark-field imaging 26–28, 98–101
  - dead time, of detector 205
  - Debye rings 58
  - degenerate vibrations 290
  - dehydration 149–151
  - density of state 167
  - depth of field 6–7, 141–143
  - depth of focus 7
  - depth resolution 277
  - derivative thermogravimetry 361
  - detection limit 277
  - detection sensitivity 277
  - deuterated triglycine sulfate (DTGS) 301
  - deviation vector 119
  - diamond saw 16
  - diatomic model, of molecular vibration 285, 290
  - dichroic mirror 37–38
  - differential interference contrast (DIC) 15, 35–36
  - differential mode spectrum 233
  - differential scanning calorimetry (DSC) *See also* differential thermal analysis (DTA) 337–340
    - application to polymers 351–353
    - enthalpy change measurement 347
    - heat capacity determination 348–350
    - temperature-modulated differential scanning calorimetry (TMDSC) 340–342
  - differential thermal analysis (DTA) *See also* differential scanning calorimetry (DSC) 337, 339–340, 348
    - baseline determination 343–344
    - calibration of temperature and enthalpy change 348
    - phase transformation and phase diagrams 350–351
    - sample requirements 342–343
    - scanning rate effects 344–345
    - transition temperatures 345–347
    - working principles 337–338
  - diffraction contrast 96–101
  - diffraction grating 311, 313–314
  - dipole moment of molecule 293
  - diffuse reflectance 305–306

direct collision sputtering 254  
 direct comparison method 74–75  
 direct imaging method 315  
 direct mode spectrum 233  
 dislocations 122–124  
 double refraction. See birefringence  
 double transmission 306  
 double-tilt holder 89–90  
 duoplasmatron source 259–260  
 dynamic mode 174–175  
 – noncontact mode 177–178  
 – applications 181–183  
 dynamic range 277  
 dynamic secondary ion mass spectrometry  
 253, 257

**e**

elastic scattering 130, 287–288  
 electric discharge machine (EDM) 16  
 electrolytic polishing 22–23  
 electrolytic thinning 91–92  
 electromagnetic lenses 87–89, 128  
 electromagnetic radiation 283–284  
 electron backscatter diffraction (EBSD) 151  
 – applications 155–156  
 – indexing and automation 153–155  
 – pattern formation 151–153  
 electron bombardment sources 259–260  
 electron channeling contrast. See  
 crystallographic contrast  
 electron energy analyzers 229–230  
 electron energy resolution 229  
 electron flood gun 241, 266  
 electron gun 228–229  
 electronic gate 260  
 electron number effect 138–139  
 electron retardation 216, 229  
 electron sources 84–85, 87  
 – field emission gun 86–87  
 – thermionic emission gun 85–86  
 electron spectroscopy 221  
 – Auger electron spectroscopy 222–225  
 – characteristics  
 – – Auger electron spectra 233–235  
 – – photoelectron spectra 230–233  
 – – compositional depth profiling 247–249  
 – instrumentation 225  
 – – electron energy analyzers 229–230  
 – – electron gun 228–229  
 – – electronic gate 280  
 – – ion gun 229, 247  
 – – ultrahigh vacuum system 225–227  
 – X-ray gun 227–228  
 – qualitative analysis 235, 237–239

– – chemical shifts 239–241  
 – – insulating material problems 241–245  
 – – peak identification 239  
 – quantitative analysis  
 – – peaks and sensitivity factors 246–247  
 – – X-ray photoelectron spectroscopy  
 221–222  
 electronic gate 280  
 electrostatic forces 171–172  
 elliptically polarized light 32  
 emission volume 210  
 endothermic thermal event 337, 339  
 energy dispersive spectroscopy (EDS) 127,  
 197, 203–208  
 – advances 204–206  
 – detector 203–204  
 – scanning modes 210–211  
 – special features 208–210  
 enthalpy change 334–335  
 environmental scanning electron microscope  
 (ESEM) 156  
 – applications 158–159  
 – working principle 156–158  
 epi-illumination 12, 37, 38  
 etchants 23–25  
 etching 23–26  
 Everhart–Thornley (E–T) detector 130  
 Ewald sphere 55–58, 96, 108  
 exciter filter 37  
 exothermic thermal event 337, 339  
 external standard method 74  
 eyepiece 1–3, 15  
 – dept of field improvement 15  
 – optimum resolution steps 15

**f**

face-centered cubic (FCC) structure 111, 119  
 far-field interactions 163  
 Faraday cage 130, 141  
 Fermi level 167  
 field diaphragm 11–12  
 field emission gun 86–87, 127, 131  
 final thinning 91  
 – electrolytic thinning 91–92  
 – ion milling 92–93  
 – ultramicrotomy 93–94  
 fingerprint region 324  
 first-order phase transition 334  
 flood gun 266–267  
 fluorescence factor 217  
 fluorescence microscopy 37–39  
 fluorescent labeling 37  
 fluorescent yield 195–197  
 fluorochromes 37

force modulation 179–180  
 – applications 182  
 force sensors 172–174  
 Fourier transform (FT) 103–104, 275  
 Fourier Transform infrared spectroscopy (FTIR) 297–298  
 – examination techniques  
 – – liquid and gas sample preparation 304–305  
 – – microspectroscopy 307–310  
 – – reflectance 305–306  
 – – solid sample preparation 304  
 – – transmittance 304  
 – instrumentation  
 – – beamsplitter 300–301  
 – – Fourier Transform infrared spectra 302–304  
 – – infrared detector 301  
 – – infrared light sources 300  
 – working principles 298–300  
 freeze drying 150–151  
 friction force microscopy. See lateral force microscopy  
 fundamental parameter method 215  
 fusible line method 359  
 fusion enthalpy 351

**g**

gas–discharged tubes 10  
 gaseous detection devices (GDD) 158  
 Globar 300  
 goniometer circle 64  
 grinding 19–21, 91  
 group theory 292

**h**

Hamasker constant 171  
 hand grinding 19–20  
 hand polishing 21–22  
 harmonic vibrations 285  
 heat 335  
 heat filters 13  
 heat flux differential scanning calorimetry 338, 339  
 heat tinting 26  
 hemispherical sector analyzer 229  
 Hertz model 176  
 high-resolution transmission electron microscopy (HRTEM) 101  
 high-resolution X-ray diffractometry (HRXRD) 64–65  
 holographic filter 311, 312  
 hot mounting 17–18  
 Hough transform 154

**i**

illumination system 9–13  
 image artifacts 183  
 – scanner 185–187  
 – tip 184–185  
 – vibration and operation 187–188  
 image formation 1–3  
 imaging modes 26, 94–95  
 – bright–field and dark–field imaging 26–27  
 – diffraction contrast 96–101  
 – fluorescence microscopy 37–39  
 – mass-density contrast 95–97  
 – Nomarski microscopy 35–37  
 – phase contrast 101–106  
 – phase-contrast microscopy 27–30  
 – polarized-light microscopy 30–35  
 immersion etching 24  
 inelastic scattering 130  
 – See also Raman scattering 115, 311  
 infinity-corrected optics 2  
 infrared absorption 286–287  
 infrared activity 292–295  
 inphase 52  
 instrument baseline 343  
 interface smearing 248–249  
 interference filters 13  
 interferogram 298–300  
 intermittent contact mode. See tapping mode  
 internal standard method 74, 214–215, 330  
 interpretable structure image 105  
 ion gun 229, 247  
 ion milling 92–93  
 ionization probability 255–256, 278

**k**

$K\alpha$  doublet 50  
 Köhler system 10–12  
 Kikuchi lines 114–117  
 Kikushi band 152–154  
 kinetic component, of heat flow 341

**l**

lanthanum hexaboride gun 85–86  
 laser scanning 40  
 laser source 311  
 lattice vibrations 286  
 lens aberrations 7  
 lifetime, of surface 257–258  
 light dispersion 7  
 light filters 12–13  
 light guide 130  
 light microscopy 1  
 – confocal laser scan microscopy (CLSM) 39

- three-dimensional images 41–43
- working principles 39–40
- imaging modes 26
- bright-field and dark-field imaging 26–27
- fluorescence microscopy 37–39
- Nomarski microscopy 35–37
- phase-contrast microscopy 27–30
- polarized-light microscopy 30–35
- instrumentation 9
- eyepiece 15
- illumination system 9–13
- objective lens 13–15
- optical principles
  - aberrations 7–9
  - depth of field 6–7
  - image formation 1–3
  - resolution 3–6
- specimen preparation 15–16
  - etching 23–26
  - grinding 19–21
  - mounting 17–19
  - polishing 20–23
  - sectioning 16–17
- linear absorption coefficient 50
- liquid-metal ion sources 260–261
- local density of states (LDOS) 167–168

**m**

- machine grinding 20
- magnetic contrast 141
- magnetic quantum number 193
- magnetic sector analyzer 263–264
- magnification 3
- manipulation mode 168–169
- mass absorption coefficient 50–51
- mass analysis system 262–263
  - magnetic sector analyzer 263–264
  - quadrupole mass analyzer 264, 267
  - time-of-flight analyzer 264–265
- mass density 50
- mass resolution 263
- mass-density contrast 95–97
- mass-to-charge ratio 263
- matrix factor 214
- mechanical clamping 18
- mercury cadmium telluride (MCT) 301, 307
- metallography 1, 23
- Michelson interferometer 298, 313–314
- microanalysis 208
- micro-Raman. See Raman microscopy
- Miller indices 53, 61, 66, 111
- Moseley's Law 192
- mounting 17–19

- mull method 304
- multicrystal diffraction 114
- multiplet splitting 233

**n**

- n-mer region 271
- near-field forces 170–171
  - capillary forces 172
  - electrostatic forces 171–172
  - short-range forces 171
  - van der Waals forces 171
- near-field interactions 163
- Nernst glower 300
- neutral density (ND) filters 13
- Nomarski microscopy 35–37
- normal mode, of molecular vibrations 289–291
  - classification of normal vibration modes 291–292
  - number of normal vibration modes 291
- null-point microbalance 354
- numerical aperture (NA) 3, 13–14

**o**

- object 1
- object functions 102–103
- objective lens 1, 2, 13–15, 102–104, 128
- oligo-scattering condition 157
- oligomer region 271
- Olympus light microscope 10
- opening angle 184
- operational modes 168–176
  - dynamic operational modes 177–180
  - lateral force microscopy 177, 181
  - static contact modes 176–177
- optical anisotropy 30, 34

**p**

- parafocusing 64
- parallel imaging method 245
- pass energy 229
- phase contrast 101–102
  - theoretical aspects 102–105
  - two-beam and multiple-beam imaging 105–106
- phase identification, with Raman spectroscopy 317–318
- phase imaging 179
- phase plate 29
- phase shift 104
- phase-contrast microscopy 27–30
- photoelectron spectra 230–233
- photomultiplier tube 130
- photon energy 284

- piezoelectric materials 165
  - pinhole aperture 39
  - pinhole spatial filter 311–312
  - plane-polarized light 31
  - plasma ion sources 259
  - plasma-magnetron sputtering 149
  - Plasmon loss 233
  - pleochroism 33
  - polarizability 295
  - polarizability ellipsoid 295–297
  - polarization factor 59
  - polarized-light microscopy 30–35
  - polarizer 31
  - polishing 20–23
  - polishing cloth 21
  - polymer identification, with Raman spectroscopy 319
  - potassium bromide 300
  - powder diffraction file (PDF) 70–73
  - power-compensated differential scanning calorimetry 339, 347
  - prefilters 312–313
  - pressure-limiting aperture (PLA) 156–157
  - primary absorption 214
  - primary beam
    - analysis area 279–280
    - energy 278
    - incident angle 278–279
  - primary ions 258–259, 266
    - sources 259–261
    - Wien filter 262
  - principal quantum number 193
  - probe diameter 131
  - projector lens 1
- q**
- quadrupole mass analyzer 264
  - quantitative differential thermal analysis (DTA). See heat flux differential scanning calorimetry
  - quantum numbers 193
- r**
- Raman active 292
  - Raman activity 292–293, 295–297
  - Raman imaging 315–316
  - Raman microscopy 310
    - applications 316–323
    - fluorescence problem 314–315
    - instrumentation 310–314
    - Raman imaging 315–316
  - Raman scattering 287–288
  - Raman shift 289, 314, 327
  - Raman spectra quantitative analysis 330
  - raster 39
  - ratio method 329–330
  - reciprocal lattice 53–55
  - reflected-light microscopes 9, 23, 28, 30
  - reflection-absorption 305
  - relay lens 12
  - remote aperture 307
  - residual strain determination with Raman spectroscopy 321–322
  - resolution 3–5
    - brightness and contrast 5–6
    - effective magnification 5
  - Rose viability criterion 134
  - rotation angle 112
- s**
- sample baseline 343–344
  - scan coils 128
  - scanning Auger microscopy 225
  - scanning electron microscopy (SEM) 83, 127, 207–208, 225, 315
    - contrast formation 135
    - – compositional contrast 139–141
    - – electron-specimen interactions 135–137
    - – topographic contrast 137–139
  - electron backscatter diffraction (EBSD) 151
    - – applications 155–156
    - – indexing and automation 153–155
    - – pattern formation 151–153
  - environmental scanning electron microscope (ESEM)
    - – applications 158–159
    - – working principle 156–158
  - instrumentation
    - – optical arrangement 127–129
    - – probe size and current 131–135
    - – signal detection 129–131
  - operational variables 141
    - – acceleration voltage and probe current 144
    - – astigmatism 145
    - – working distance and aperture size 141–143
  - specimen preparation 145–146
    - – dehydration 149–151
    - – microcomposition examination preparation 149
    - – topographic examination preparation 146–149
  - scanning force microscope (SFM). See atomic force microscope (AFM)

- scanning method, for compositional imaging 244–245
  - scanning probe microscopy (SPM) 163
    - atomic force microscopy (AFM)
      - – dynamic noncontact mode applications 177–183
      - – force modulation applications 182
      - – force sensors 172
      - – near-field forces 170–172
      - – operational modes 174–180
      - – static mode applications 180–181
      - – tapping mode applications 182
    - image artifacts 183
    - – scanner 185–187
    - – tip 184–185
    - – vibration and operation 187–188
  - instrumentation 163–164
    - – control and vibration isolation 165–166
    - – instrumentation 165
  - scanning tunneling microscopy (STM)
    - – applications 169–170
    - – operational modes 168–169
    - – probe tips and working environments 167–168
    - – tunneling current 166–167
- scanning tunneling microscopy (STM) 163, 165–166
  - applications 169–170
  - operational modes 168–169
  - probe tips and working environments 167–168
  - tunneling current 166–167
- scattering vector magnitude 79
- scintillator 130
- second-order phase transition 334
- secondary absorption 214
- secondary electrons (SEs) 129–130, 135, 137, 139, 141
- secondary fluorescence 214
- secondary ion mass spectrometry (SIMS) 253
  - basic principles 253–254
    - – dynamic and static SIMS 257–258
    - – generation 254–257
    - – depth profiling 275–276
    - – generation 276–277
    - – optimization 276–280
  - imaging 272
    - – generation 274
    - – quality 275
  - instrumentation 258
    - – mass analysis system 262–265
    - – primary ion system 258–262
  - surface structure analysis 266
    - – experimental aspects 266–268
    - – spectrum interpretation 268–272
- second-order phase transition 334
- sectioning 16
  - cutting 16–17
  - microtomy 17
- selected-area diffraction (SAD) 107
  - characteristics 107–109
    - Kikuchi lines 114–117
  - multocrystal diffraction 114
  - single-crystal diffraction 109–114
- semiachromatic lens 14
- sensitivity factor 246–247
- shake-up satellites 231–233
- short-range forces 171
- Siegbahn Notation 194
- signal detection and SEM 129–130
  - detector 130–131
- single-beam spectrum 302
- single-crystal diffraction 109
  - crystal phase identification 112–114
    - cubic crystal pattern indexing 89–112
- single-tilt holder 89
- slow collision sputtering 276
- small-angle X-ray scattering (SAXS) 79
- Soller slits 62
- specimen scanning 39–40
- spectroscopic mode 168
- specular reflectance 305–306
- spherical aberration 7–8, 104
- spin quantum number 193
- sputtering 148–149
  - collision sputtering 254
    - direct collision sputtering 254
    - plasma–magnetron sputtering 149
    - slow collision sputtering 254
    - thermal sputtering 254
  - sputter yield 247–248, 281
- stage number 320
- standardless quantitative analysis 217–218
- static mode 174, 174–175
  - applications 180–181
- static secondary ion mass spectrometry 253, 257–258
- Stokes scattering 289
- stopping factor 216
- structure extinction 60–61
- structure factor 61
- submonomer region 269, 271
- surface ionization sources 261
- surface structure analysis 266
  - experimental aspects
    - – flood gun 266–267
    - – primary ions 266

- surface structure analysis (*contd.*)
  - sample handling 267–268
  - spectrum interpretation 268–269
  - element identification 269–272
- surface topography 167
- swab etching 24
- symmetric stretching mode 290
- t**
- take-off angle 208
- tapping mode 174–175, 177–179
  - applications 182
- Taylor cone 261
- thermal analysis (TA) 333
  - common characteristics
  - experimental parameters 336–337
  - instrumentation 335–336
  - thermal events 333–335
  - differential thermal analysis (DTA) and differential scanning calorimetry (DSC) 337–340, 348
  - application to polymers 351–353
  - baseline determination 343–344
  - calibration of temperature and enthalpy change 348
  - enthalpy change measurement 347
  - heat capacity determination 348–350
  - phase transformation and phase diagrams 350–351
  - sample requirements 342–343
  - scanning rate effects 344–345
  - temperature-modulated differential scanning calorimetry (TMDSC) 340–342
  - transition temperatures 345–347
  - working principles 337–338
  - thermogravimetry (TG) 353–354
  - applications 362–364
  - atmosphere 356
  - curve types 356–358
  - heating rate 359
  - instrumentation 354–355
  - samples 355–356
  - temperature calibration 358–359
  - temperature determination 361, 362
- thermal drift 168, 186
- thermal events 333–334
  - enthalpy change 335
- thermal field emission gun 86
- thermal sputtering 254
- thermionic emission gun 85–86
- thermobalance 353
- thermogravimetry (TG) 353–354
  - applications 362–364
  - atmosphere 356
  - curve types 360–361
  - heating rate 359
  - instrumentation 354–355
  - samples 355–356
  - temperature calibration 358–359
  - temperature determination 362
- thin-film X-ray diffractometry 63
- time-of-flight analyzer 264–265
- time-of-flight secondary ion mass spectrometry (TOF SIMS) 262, 270–272
- tint etching 24, 26
- tip geometry 184–185
- tip jump-off-contact 175
- tip jump-to-contact 175
- topographic contrast 137–139
- topographic examination preparation 146–147
  - surface charging and prevention 147–149
- total reflection X-ray fluorescence spectrometer (TRXRF) 205–206
- trajectory effect 137–138
- transfer function 104
- transmission 255
- transmission electron microscopy 83
  - crystal defect images 117
  - bending contours 120–122
  - dislocations 122–124
  - wedge fringe 117–120
  - image modes 94–95
  - diffraction contrast 96–101
  - mass-density contrast 95–97
  - phase contrast 101–106
  - instrumentation 83–84
  - electromagnetic lenses 87–89
  - electron sources 84–87
  - specimen stage 89–90
  - selected-area diffraction (SAD) 107
  - characteristics 107–109
  - Kikuchi lines 114–117
  - multocrystal diffraction 114
  - single-crystal diffraction 109–114
  - specimen preparation 90
  - final thinning 91–94
  - prethinning 91
- transmittance spectrum 303
- transmitted-light microscopes 9, 23
- tungsten filament gun 85–86
- Tungsten-halogen bulbs 9–10
- tunneling current 166–167



**u**

- ultrahigh molecular weight polyethylene (UHMWPE) 79
- ultrahigh vacuum system 225–227
- ultramicrotomy 17, 93–94

**v**

- vacuum evaporating 148
- vacuum impregnation 18–19
- van der Waals forces 171
- vibrational quantum number 286
- vibrational spectroscopy, for molecular analysis 283
  - electromagnetic radiation 283–284
  - Fourier Transform infrared spectroscopy (FTIR) 297–298
  - – examination techniques 304–310
  - – instrumentation 300–304
  - – working principles 298–300
  - infrared activity 292–295
  - interpretation 323
  - – band intensities 327
  - – characteristic bands identification 324–327
  - – infrared spectra quantitative analysis 327, 329–330
  - – Raman spectra quantitative analysis 330
  - – spectrum comparison 323
  - molecular vibrations
  - – normal mode 289–292
  - – origins 285–286
  - principles
  - – infrared absorption 286–287
  - – Raman scattering 287–288
  - Raman activity 292–293, 295–297
  - Raman microscopy 310
  - – applications 316–323
  - – fluorescence problem 314–315
  - – instrumentation 310–314
  - – Raman imaging 315–316
- virtual image 1

**w**

- wave function 103–104
- wave number 284
- wavelength dispersive spectroscopy (WDS) 199–204
  - analyzing crystal 200–201
- weak-beam dark-field image 101
- wedge fringe 117–120
- Wehnelt electrode 85
- white X-rays. See continuous X-rays

- wide-angle diffraction (WAXD) 75–79
- wide-angle scattering (WAXS) 75, 79–81
- Wien filter 262
- Wollaston prisms. See differential interference contrast (DIC)
- working distance 131
  - and aperture size 141–143

**x**

- X-ray absorption factor 216–217
- X-ray diffraction methods 47
  - diffraction geometry
  - – Bragg's law 52–53
  - – Ewald sphere 55–58
  - – reciprocal lattice 53–55
  - diffraction intensity 58–60
  - – applications 70–75
  - – diffraction data acquisition and treatment 65–67
  - – diffraction spectra distortions 67–70
  - – instrumentation 62–65
  - – sample preparation 65
  - – structure extinction 60–61
  - wide-angle diffraction (WAXD) 75–79
  - wide-angle scattering (WAXS) 75, 79–81
  - X-ray diffractometry (XRD) 62
  - X-ray radiation
  - – absorption 50–51
  - – generation 47–50
- X-ray diffractometer 62, 65, 68, 196
- X-ray diffractometry (XRD) 62, 108, 211, 213
  - applications
  - – crystal-phase identification 70–72
  - – quantitative measurement 72–75
  - diffraction data acquisition and treatment 65–67
  - diffraction spectra distortions
  - – crystallite size 68–69
  - – preferential orientation 67–68
  - – residual stress 69–70
  - instrumentation 62–63
  - – system aberrations 64–65
  - sample preparation 65
- X-ray fluorescence (XRF) 191, 196, 199, 211–215
  - energy dispersive spectroscopy (EDS) 203
  - – advances 204–206
  - – detector 203–204
  - wavelength dispersive spectroscopy (WDS) 199–203
  - working atmosphere and sample preparation 206–207
- X-ray gun 227–228

- X-ray photoelectron spectroscopy (XPS)
    - 221–222, 227, 229–231, 235, 237–241, 243–245, 247–248, 250
  - X-ray photons 203–205, 210
  - X-ray scattering 59–60
  - X-ray spectroscopy 191
    - characteristic X-rays 191–193
      - – comparisons 194–196
      - – selection rules 193–194
    - energy dispersive spectroscopy (EDS) in electron microscopes 207–208
      - – scanning modes 210–211
      - – special features 208–210
    - fluorescence spectrometry (XRF) 196, 199
    - – energy dispersive spectroscopy 203–206
      - – wavelength dispersive spectroscopy (WDS) 199–203
      - – working atmosphere and sample preparation 206–207
      - qualitative analysis 211–213
      - quantitative analysis 213–214
        - – electron microscopy 216–218
        - – fundamental parameter method 215
      - – X-ray fluorescence 214–215
  - X-ray tube 48
- Z**
- ZAF method 216–217
  - zero line. See instrument baseline
  - zero path difference 298
  - zone axis direction 55