# Subject Index

Α

Abbreviations occupational safety and health, labs, 673-674 specimen preparation, 221 Abrasive cut-off machines, 36-43 design principles of wheel-work piece contact. 36-39 machine designs, 39-43 Abrasive cut-off wheels, 32-36 consumable wheels, 32-34 slow consumable wheels. 34-36 Abrasives, 18-19 aluminum oxide, 18 cubic boron nitride, 18 diamond, 18-19 polishing, 129–132 silicon carbide, 18 wet abrasive cutting, sectioning, 16-21 Acrylics occupational safety and health, labs. 668 specimen preparation, 436-439 After preparation cleaning, 82-84 Agency for Toxic Substance and Disease Registry (ATSDR), 683-684 Alcohol-based grinding/polishing fluids. 97 Alumina wet grinding paper, 105–106 Aluminum electrolytic polishing and etching, 464 specimen preparation, 352-356 Aluminum alloys, 356–358 Aluminum oxide abrasive types, 18 grinding abrasives, 93 specimen preparation, 238-240 American Conference of Government Industrial Hygienists (ACGIH), 683 Analog cameras, automatic image analysis, 614-615 Anodic etching, 172–173 Anodized coatings, specimen preparation, 247-251 Anodizing, etching, 173 Antimony, specimen preparation, 361-364

Arc of contact, metallographic/ materialographic cutting operation, 31 Archiving, 619 Artifacts of electrolytic polishing, selection of preparation method, 7 ASTM B 487, 576 ASTM C 664, 576 ASTM E 45, 570 ASTM E 112, 571-573 ASTM E 562, 569 ASTM E 930, 573 ASTM E 1077, 575 ASTM E 1122, 570 ASTM E 1181, 573 ASTM E 1245, 570 ASTM E 1268, 574 ASTM E 1382, 573 ASTM E 1578. 619 ASTM E 2014, 668, 674 ASTM E 2109, 574-575 ASTM standards cutting fluids, wet abrasive cutting, 29 hardness, 625 metallography, 188-193 Atomic force microscope (AFM), 561 Automatic grinding equipment, 119, 135 Automatic image analysis, 577–617 analog cameras, 614-615 automatic measurements, 600-602 background correction, 586-588 banding degree, 608 brightness and contrast, 581-586 cameras, 614-615 compacted graphite, 613 computers, 614 contrast stretching, 588-589 depth measurements, 608-610 digital cameras, 615-616 digital imaging, 579, 602-613 digital imaging technology, 613-616 ductile cast iron, 611-613 grain size, 606-608 graphite in iron castings, 610-611 gray cast iron, 613 hardware, 613-616

histogram, 581 image acquisition, 579-580 image calibration, 595-598 image digitization, 580-581 image measurement, 598-602 image processing, 586-595 implementation, 617-618 inclusion rating, 603-606 manual measurements, 599-600 open source/public domain software, 617 percent area, 602-603 printers, 616 sharpening, 593-595 smoothing, 592-593 software, 616-617 thickness measurements, 608-610 volume fraction, 602-603 watershed filter, 590-592 Automatic measurements, automatic image analysis, 600-602 Automatic systems, polishing, 140–143 Automation labs, 651–654 Availability of NIOSH Registry of Toxic Effects of Chemical Substances, 681

# В

Background correction, automatic image analysis, 586-588 Bacteria and fungi, cutting fluids, wet abrasive cutting, 28-29 Bakelite bond, 20-21 Banding, quantitative metallography/ materialography, 574 Banding degree, automatic image analysis, 608 Bandsawing, 48-52 blades, 49-51 cutting fluids, 51 machines, 49-51 safety, 49 tips, 51–52 Barium titanate, specimen preparation, 241 Baumann hammer, 644 Before preparation start cleaning, 82 Beryllium, specimen preparation, 365-367

Bias, quantitative metallography/ materialography, 568-569 Blades, bandsawing, 49–51 Bond materials cut-off wheel, 20-21 wet abrasive cutting, sectioning, 16-21 Bones, specimen preparation, 427-430 Boron carbide grinding abrasives, 97 specimen preparation, 227–232 Brass, specimen preparation, 376–380 Brightness and contrast, automatic image analysis, 581-586 Brinell hardness testing, 626-628 British Standards Institution, 684 Brittle materials, grinding, 92-93 Bronze electrolytic polishing and etching, 467 specimen preparation, 376-380 Building labs, 649, 650-663

# С

Calcium oxide, specimen preparation, 241 Calibration, quantitative metallography/materialography, 568 Cameras, automatic image analysis, 614-615 Capacitors, specimen preparation, 298-300 Carbonitrided steels, specimen preparation, 339-342 Cement clinker, specimen preparation, 346-349 Cemented carbides, 187 Ceramic capacitors, specimen preparation, 281-284 Ceramic layers, specimen preparation, 268-270 Ceramic resistors, specimen preparation, 281-284 Ceramics deformation, grinding, 92-93 specimen material, 182 specimen preparation, 232-235

Cerium oxide, specimen preparation, 241 Chemical disposals, occupational safety and health, labs, 672-673 Chemical etching, 172 Chemical mechanical polishing (CMP), 7, 151–152 Chemical microetching, examination purpose, 194–217 Chemical polishing, 7 electrolytic polishing/etching, 168 Chips, sliding, plowing, grinding mechanics, 22 Chromium electrolytic polishing and etching, 464-465 specimen preparation, 367-370 Chromium carbide, specimen preparation, 232-235 Chromium oxide, specimen preparation, 238-240 Circular sawing, 48 Clamping, thermal damage, wet abrasive cutting, 24-25 Classical etching, 172 Classification of materials, specimen material, 181 Cleaning, 82-84 after preparation, 82-84 drying, 83 ethanol, 83 grinding disks, 84 hand, 82-83 polishing cloths, 84 before preparation start, 82 rubbing effect, 83 ultrasonic, 83 ultrasonic apparatuses, 83 Cleanliness, 84 Cloths, polishing, 124–129 Coatings, specimen material, 182-183 Cobalt electrolytic polishing and etching, 465-466 specimen preparation, 370-373 Cobalt-based super alloys, specimen preparation, 373–376 Cold mounting resins, occupational safety and health, labs, 667

Color etching, 172 Color ratings system, occupational safety and health, labs, 669 Compacted graphite, automatic image analysis, 613 Comparison procedure, quantitative metallography/materialography, 571-572 Composites specimen material, 183 specimen preparation, 276-281 Compressed air, cleaning, 83 Computers, automatic image analysis, 614 Concrete, specimen preparation, 346-349 Confocal laser scan microscope, 552 - 555Consumable abrasive cut-off wheels storing, 33-34 wheel dimensions, 33 wheel velocity, 32-33 Consumables, specimen preparation, 221 Contemporary grinding, 106-117 diamond film, 109 diamond pads, 109 fine grinding cloths, 116 magnetic fixation, 106-107 metal-bonded diamond-coated disks, 109 resin-bonded diamond grinding disks, 107-108 resin-bonded SiC grinding disks, 108 rigid composite disks, 109–116 Contrast stretching, automatic image analysis, 588-589 Cooling, cutting fluids, 26 Cooling system, cutting fluids, wet abrasive cutting, 27-28 Copper electrolytic polishing and etching, 466 specimen preparation, 376-380 Copper-bearing alloys, specimen preparation, 380-383 Cubic boron nitride, abrasive types, 18 Cubic boron nitride (CBN), grinding abrasives, 97 Cut-off grinding process, wet abrasive cutting, sectioning, 15-16 Cut-off wheel abrasive types, 18-19 bond material, 20-21 grade, 20 grain size, 19-20 rpm, 30 selection, 44-45 specifications, 16-18 structure, 20 truing and dressing, 26 wear, 25–26 wet abrasive cutting, sectioning, 16-21 Cutting fluids, 26–29 ASTM standards, 29 bacteria and fungi, 28-29 bandsawing, 51 cooling system, 27-28 grinding fluid application, 27 grinding fluid concentration, 28 grinding fluid disposal, 29 health and safety aspects, 29 lubrication and cooling, 26 synthetic grinding fluids-oilbased, 26-27 water quality, 28 CVD coatings, specimen preparation, 247-251

# D

Dangers, occupational safety and health, labs, 664 Dark-field illumination (DF), etching, 169 Decarburization, quantitative metallography/materialography, 575–576 Deformation, 89–93 brittle materials, 92–93 ceramics, 92–93 grinding, 86 metals, 89–92 polishing, 122–124 Depth measurements, automatic image analysis, 608-610 Design principles of wheel-work piece contact abrasive cut-off machines, 36-39 direct cutting. 36 oscillating cutting, 36-37 rotating work piece, 39 step cutting, 38-39 **Diamond products** abrasive types, 18-19 film, 109 fixed grains, 95 grinding abrasives, 94-96 loose grains, 95-96 monocrystalline, 94 pads, 109 pastes, 96 polycrystalline, 94 sprays, 96 suspensions, 96 Differential interference contrast (DIC), etching, 169 Diffusion coatings, specimen preparation. 251-254 Digital cameras, automatic image analysis, 615-616 Digital image management, 619 Digital imaging, automatic image analysis, 579, 602-613 Digital imaging technology, automatic image analysis, 613-616 Diodes, specimen preparation, 281-284 Direct cutting, design principles of wheel-work piece contact, 36 Documentation, optical reflected light microscope, 550-552 Drving, cleaning, 83 Ductile cast iron, automatic image analysis, 611-613 Dust, occupational safety and health, labs, 667 Dynamic hardness testing procedures, 644-645

#### Ε

Economy, grinding, traditional, 105 Edge retention, grinding, traditional, 103–105 Education, labs, 651 Electric discharge machining (EDM), sectioning by melting, 46 Electrolytes, polishing/etching, 163–164 Electrolytic polishing and etching, 172-173, 453-475 aluminum, 464 bronze, 467 chromium, 464-465 cobalt, 465-466 copper, 466 gray cast iron, 459 hard metals, 474-475 heat treated steels, 459-460 high carbon steels, 457 high-speed steels, 462-463 iron, 462 lead, 467-468 low-alloyed tool steels, 463 low carbon steels, 457-458 magnesium, 468-469 nickel, 469 silver, 469-470 stainless steels, 460-461 super alloys, 461 tin, 470-471 titanium, 471 tungsten, 472 vanadium, 472-473 zinc, 473 zirconium, 474 Electrolytic polishing/etching, 156-168 chemical polishing, 168 electrolytes, 163-164 electrolytic thinning for transmission electron microscope (TEM), 167-168 electropolishing in practice, 164-165 equipment, 165-166 field metallography, 166-167 nondestructive electropolishing, 166-167 occupational safety and health, labs, 665 process, 156-163 Electrolytic polishing etching, artifacts, 7 Electrolytic thinning for transmission

electron microscope (TEM), 167-168 Electrolytically deposited coatings, 251-254 Electron backscatter diffraction (EBSD), 559-560 polishing, 149–150 Electron microscopy, 558-561 atomic force microscope (AFM), 561 electron backscatter diffraction (EBSD), 559-560 electron probe microanalyzer (EPMA), 560 energy dispersive spectroscopy (EDS), 559 focused ion beam (FIB), 560 magnetic force microscopy (MFM), 561 scanning electron microscope (SEM), 558-559 scanning probe microscopes (SPM), 560-561 scanning transmission electron microscope (STEM), 558 transmission electron microscope (TEM), 558 Electron probe microanalyzer (EPMA), 560 Electropolishing in practice, 164-165 Energy dispersive spectroscopy (EDS), 559 Engraving, marking, 80 Environment, grinding, traditional, 105 **Environmental Protection Agency** (EPA), 683 EPDM polymers, 430-436 Epoxy, occupational safety and health, labs, 667 Equipment electrolytic polishing/etching, 165-166 labs, 656-660 Equotip tester, 645 Etchant names, examination purpose, 217 Etching, 169-176 anodic, 172-173 anodizing, 173 chemical, 172

classical, 172 color, 172 dark-field illumination (DF), 169 differential interference contrast (DIC), 169 electrolytic, 172-173 examination purpose, 194 fluorescence, 170 grain boundary etching, 171 grain contrast etching, 170-171 heat tinting, 172 ion, 173-174 macroetching, 174-175 microetching, 169 microscope techniques, 169-170 occupational safety and health, labs, 665-666 physical, 173-174 polarized light (POL), 169-170 potentiostatic, 173 precipitation, 172 preparation process, 13 reactive sputtering, 174 relief polishing, 173 reproducibility, 171-172 sputtering, 174 thermal, 174 vapor deposition, 174 Ethanol, cleaning, 83 European Union (EU), occupational safety and health, labs, 669-670, 684 Examination purpose, 179, 188 ASTM standards, 188-217 chemical microetching, 194-217 etchant names, 217 etching practice, 194 Eyepieces, optical reflected light microscope, 535-536

# F

Failure analysis, labs, 651
Feed speed, metallographic/ materialographic cutting operation, 30–31
Ferrous metals, specimen material, 183–184
Field metallography

electrolytic polishing/etching, 166-167 polishing, 150-151 Field metallography/materialography, specimen preparation, 475-476 Field selection, quantitative metallography/materialography, 568-569 Fine grinding, 86, 119 Fine grinding cloths, 116 Fixed grains, diamond products, 95 Flammable and Combustible Liquids, 680 Flammable liquids, occupational safety and health, labs, 667 Fluorescence, etching, 170 Focused ion beam (FIB), 560 Force material removal, grinding, 89 metallographic/materialographic cutting operation, 30 Fracturing, sectioning, 45 Free cutting, 31–32 automatics, 32 hand. 32

# G

Galvanization, specimen preparation, 251-254 General Description and Discussion of the Levels of Protection and Protective Gear, 680-681 General studies or routine work, 14 General use, machine designs, abrasive cut-off, 40-41 Generic methods, specimen preparation, 219 Germanium, specimen preparation, 288-291 Glasses, specimen preparation, 244-247 Gold, specimen preparation, 384–387 Grades cut-off wheel, 20 hard, 20 soft, 20 Grain boundary etching, 171 Grain contrast etching, 170-171

Grain penetration, material removal, grinding, 89 Grain shape, material removal, grinding, 88 Grain size automatic image analysis, 606-608 cut-off wheel, 19-20 quantitative metallography/ materialography, 571-573 Graphite in iron castings, automatic image analysis, 610–611 Gray cast iron automatic image analysis, 613 electrolytic polishing and etching, 459 specimen preparation, 315-318 Grinding, 85-86 chips, sliding, plowing, 22 contemporary, 106-117 deformation, 86, 89-93 fine, 86 material removal, 86-89 plane, 85 traditional, 99-106 wet abrasive cutting, sectioning, 21-22 Grinding, traditional, 99-106 alumina wet grinding paper, 105-106 economy, 105 edge retention, 103-105 environment, 105 relief, 103-105 SiC wet grinding paper, 100-105 stones/disks, 99-100 zirconia alumina wet grinding paper, 105-106 Grinding abrasives, 93-97 aluminum oxide, 93 boron carbide, 97 cubic boron nitride (CBN), 97 diamond, 94-96 silicon carbide, 93 Grinding disks cleaning, 84 Grinding fluid application, 27 concentration, 28 disposal, 29

Grinding/polishing equipment, 117–119 automatic grinding, 119 fine grinding, 119 manual grinding, 117–119 plane grinding, 117–119 Grinding/polishing fluids, 89, 97–99 alcohol-based, 97 oil-based, 98–99 water-based, 97 water-oil based, 98 Grit number, 19

#### Η

Hacksawing, 48 Hand cleaning, 82-83 Hard grade, 20 Hard metals, electrolytic polishing and etching, 474-475 Hardness, 623-625 ASTM standards, 625 indentation, 623-624 testing special methods, 646 Hardness values conversion, 642-643 precision, 642 Hardware, automatic image analysis, 613-616 Hazard Communication Standard (HCS), OSHA standard, 674-679 Health and safety aspects, cutting fluids, 29 Heat tinting, etching, 172 Heat treated steels, electrolytic polishing and etching, 459-460 High-alloy steels, specimen preparation, 325-328 High carbon steels electrolytic polishing and etching, 457 specimen preparation, 307-311 High-speed steels electrolytic polishing and etching, 462-463 specimen preparation, 343-346 Histogram, automatic image analysis, 581 HMIS, occupational safety and health, labs, 670

Hot dip zinc coatings, specimen preparation, 254–257 Human eye, light microscopy, 526–527 Hydroxyapatite (HA) coating, specimen preparation, 223–226

#### L

Identification tag marking, 80 Illumination, optical reflected light microscope, 536-537 Image acquisition, 579-580 calibration, 595-598 digitization, 580-581 measurement, automatic image analysis, 598-602 processing, automatic image analysis, 586-595 Implementation, automatic image analysis, 617-618 Inclusion rating automatic image analysis, 603-606 quantitative metallography/ materialography, 570 Indentation hardness, 623-624 Instrumented indentation testing, 641-642 Integrated circuits. specimen preparation, 301-305 Intercept procedure, quantitative metallography/materialography, 572-573 International Chemical Safety Cards, 682–683 Ion etching, 173-174 Iron, electrolytic polishing and etching, 462

# J

Job Safety Analysis (JSA), 670-672

# Κ

Knoop hardness testing, 633-634

#### L

Laboratory information management systems (LIMS), 619 Labs, 649 automation, 651-654 building, 649, 650-663 education, 651 equipment, 656-660 failure analysis, 651 layout, 660-662 maintenance, 662-663 occupational safety and health, 649, 664-684 planning, 654-656 purpose, 650 quality control, 650 rationalization, 651-654 research, 651 running, 649 testing and inspection labs, 651 Laser torching, sectioning by melting, 46 Layout, labs, 660-662 Lead electrolytic polishing and etching, 467-468 specimen preparation, 387-391 Light microscopy, 525-527 human eye, 526-527 magnification, 527 magnifying lens and microscope, 527 visible light, 525-526 List of Highly Hazardous Chemicals, Toxics and Reactives, OSHA standards, 680 Literature, occupational safety and health, labs, 684-686 Loose grains, diamond products, 95-96 Low-alloy steels, specimen preparation, 336-339 Low-alloyed steels, electrolytic polishing and etching, 463 Low carbon steels electrolytic polishing and etching, 457-458 specimen preparation, 311-314 Lubricants, 97-99

cutting fluids, 26

#### Μ

Machine designs, 39-43 general use, 40-41 polishing, 135-139 precision, 41-43 Machines, bandsawing, 49-51 Macroetching, 174-175 Magnesium electrolytic polishing and etching, 468-469 specimen preparation, 391-394 Magnesium oxide, specimen preparation, 241 Magnetic fixation, contemporary grinding, 106-107 Magnetic force microscopy (MFM), 561 Magnification, light microscopy, 527 Magnifying lens and microscope, 527 Maintenance, labs, 662-663, 673 Malleable cast iron, specimen preparation, 315-318 Manganese, specimen preparation, 395-397 Manual grinding equipment, 117-119, 135 Manual measurements, automatic image analysis, 599-600 Marking, 80 engraving, 80 identification tag, 80 stamping, 80 with waterproof ink, 80 Martens scratch hardness, 646 Material exam, 179 Material removal, 86-89 force on specimens, 89 grain penetration, 89 grain shape, 88 grinding, 86 grinding/polishing fluids, 89 polishing, 120-122 rake angle, 87-88 Material Safety Data Sheet (MSDS), occupational safety and health, labs, 670-672 Materialographic specimen, 7-9

specimen or sample, 8-9 Materialography, 3 Mechanical damage, wet abrasive cutting, 22-23 unplane surface, 23 waviness, 23 Mechanical polishing artifacts, selection of preparation method, 7 Mechanical preparation, occupational safety and health, labs, 665 Mechanical surface preparation. see grinding Medium carbon steels, specimen preparation, 307-311 Metal-bonded diamond-coated disks, contemporary grinding, 109 Metallographic/materialographic cutting operation arc of contact, 31 cut-off wheel rpm, 30 feed speed, 30-31 force, 30 free cutting, 31-32 power, 31 wet abrasive cutting, sectioning, 29-32 wheel velocity, 30 Metallographic/materialographic preparation, 5-6 Metallography, 3 Metals, deformation, grinding, 89-92 Microelectronic material, specimen preparation, 291-293 Microelectronic materials, polishing, 143-147 Microelectronic packages polishing, 147-149 specimen preparation, 295-298, 301-305 Microetching, 169 Microindentation hardness, 636-639 Microscopes options, 537-538 techniques, etching, 169-170 Microtomy, polishing, 155 Mineralogical materials, specimen material, 184 Minerals, ores, specimen preparation, 349-352

Mohs scratch hardness, 646 Molybdenum, specimen preparation, 398–401 Monocrystalline, diamond products, 94 Mounting occupational safety and health, labs, 664–665 preparation process, 11

#### Ν

National Fire Protection Association (NFPA), 684 National Paint and Coatings Association, 684 National Technical Information Service (NTIS), 683 National Toxicology Program (NTP), 683 NFPA 704 Hazard Identification Ratings System, 668-669 Nickel electrolytic polishing and etching, 469 specimen preparation, 402-405 NIOSH standards, 681-682 Nodular cast iron, specimen preparation, 319-321 Nondestructive electropolishing, electrolytic polishing/etching, 166-167 Nonferrous metals, specimen material, 184-186

# 0

Occupational Exposure to Hazardous Chemicals in Laboratories, 679–680 Occupational Safety and Health Administration (OSHA) standards Availability of NIOSH Registry of Toxic Effects of Chemical Substances, 681 Flammable and Combustible Liquids, 680 General Description and Discussion of the Levels of

Protection and Protective Gear. 680-681 Hazard Communication Standard (HCS), 674-679 List of Highly Hazardous Chemicals, Toxics and Reactives, 680 Occupational Exposure to Hazardous Chemicals in Laboratories, 679-680 Occupational safety and health labs, 649.664-684 abbreviations, 673-674 acrylics, 668 Agency for Toxic Substance and Disease Registry (ATSDR), 683-684 American Conference of Government Industrial Hygienists (ACGIH), 683 ASTM E 2014, 668, 674 British Standards Institution, 684 chemical disposals, 672-673 cold mounting resins, 667 color ratings system, 669 dangers, 664 dust. 667 electrolytic polishing/etching, 665 **Environmental Protection Agency** (EPA), 683 epoxy, 667 etching, 665-666 EU system, 669-670 European Union (EU), 684 flammable liquids, 667 HMIS, 670 International Chemical Safety Cards, 682-683 Job Safety Analysis (JSA), 670-672 literature, 684–686 maintenance and service, 673 Material Safety Data Sheet (MSDS), 670-672 mechanical preparation, 665 mounting, 664-665 National Fire Protection Association (NFPA), 684 National Paint and Coatings Association, 684

National Technical Information Service (NTIS), 683 National Toxicology Program (NTP), 683 NFPA 704 Hazard Identification Ratings System, 668-669 NIOSH standards, 681-682 OSHA standards, 674-681 polyesters, 668 risk phrases, 670 safety information, 668-672 sectioning, 664 Standard Operating Procedure (SOP), 670-672 standards, 673 toxic substances, 666 training, 673 Oil-based grinding/polishing fluids, 98-99 Open source/public domain software, image analysis, 617 Optical examination methods, reflected light microscope, 540-546 Optical fibers, specimen preparation, 244-247 Optical reflected light microscope, 528-555 confocal laser scan microscope, 552-555 documentation, 550-552 eyepieces, 535-536 illumination, 536–537 microscope options, 537-538 optical examination methods, 540-546 path of light rays, 528 practical use of microscope, 546-550 reflected-light microscope, 538-540 stereo microscopy, 555-557 Ores, specimen preparation, 349–352 Organic materials, specimen material, 186-187 Oscillating cutting, design principles of wheel-work piece contact, 36-37

Oxyacetylene torching, 46

#### Ρ

Paint layers, specimen preparation, 257-260 Palladium, specimen preparation, 406-409 Parameters, specimen preparation, 220-221 Pastes, diamond products, 96 Path of light rays, optical reflected light microscope, 528 PCB coupon, specimen preparation, 305-307 Percent area, automatic image analysis, 602-603 Phenolic bond, 20-21 Physical etching, 173-174 Pitting, 9 Plane grinding, 85, 117-119 Planimetric procedure, quantitative metallography/materialography, 572 Planning, labs, 654-656 Plasma spray coatings, specimen preparation, 265-267, 270-273 Plasma torching, sectioning by melting, 46 Plated coatings, specimen preparation, 251-254 Point count, quantitative metallography/materialography, 569 Polarized light (POL), etching, 169-170 Poldi impact hardness tester, 644 Polishing, 120-155 abrasives, 129-132 automatic grinding/polishing equipment, 135 automatic systems, 140-143 chemical mechanical polishing (CMP), 151-152 cloths, 84, 124-129 deformation, 122-124 dynamics, 139-140 electron backscatter diffraction (EBSD), 149-150 field metallography, 150-151 machine design, 135-139 manual grinding/polishing equipment, 135 material removal, 120-122

microelectronic materials, 143 - 147microelectronic packages, 147 - 149microtomy, 155 polishing dynamics, 139-140 preparation methods, 132-134 printed circuit boards (PCB), 143 rough, 120 semiautomatic systems, 140-143 thin sections, 152-154 ultramilling, 155 Polycrystalline diamond products, 94 Polyesters, occupational safety and health, labs, 668 Polymers, specimen material, 187 Porosity in thermal spray coatings, 574-575 Potentiostatic etching, 173 Powder metals specimen material, 187 specimen preparation, 439-443 Power, metallographic/ materialographic cutting operation, 31 Power hacksawing, 48 Practical use of microscope, 546-550 Precipitation etching, 172 Precision cut-off, slow consumable wheels, 35 machine designs, abrasive, 41-43 Preparation methods polishing, 132-134 selection of preparation method, 7 Preparation process, 9-13 etching, 13 mounting, 11 sectioning, 10-11 surface preparation, 11-13 Preservation, 81 Printed circuit boards (PCB), polishing, 143 Printers, automatic image analysis, 616 Process, electrolytic polishing/etching, 156-163

Punching, shearing, 47

Purpose, labs, 650 PVD coatings, specimen preparation, 247–251

# Q

Quality control labs, 650 Quantitative metallography/ materialography, 565-576 ASTM B 487, 576 ASTM C 664, 576 ASTM E 45, 570 ASTM E 112, 571-573 ASTM E 562, 569 ASTM E 930, 573 ASTM E 1077, 575 ASTM E 1122, 570 ASTM E 1181, 573 ASTM E 1245, 570 ASTM E 1268, 574 ASTM E 1382, 573 ASTM E 2109, 574-575 banding, 574 bias, 568-569 calibration, 568 comparison procedure, 571-572 decarburization, 575-576 field selection, 568-569 grain size, 571-573 inclusion rating, 570 intercept procedure, 572-573 other standards, 576 planimetric procedure, 572 point count, 569 porosity in thermal spray coatings, 574-575 specimen preparation, 567-568 stereology, 565-567 volume fraction, 569

# R

Rake angle, material removal, grinding, 87–88 Rationalization, labs, 651–654 Reactive sputtering, etching, 174 Reflected-light microscope, 538–540 Relief

grinding, 103-105 polishing, 173 Reporting locations, 15 Reproducibility, etching, 171–172 Research labs, 651 Research studies, 14 Resin-bonded diamond grinding disks, 107 - 108Resin-bonded SiC grinding disks, 108 Resistors, specimen preparation, 293-295 Rigid composite disks, grinding, 109 - 116Risk phrases, occupational safety and health, labs, 670 Rockwell hardness testing, 634–636 Rotating work piece, 39 Rough polishing, 120 Rubber bonds, 21 Rubbing effect, cleaning, 83 Running labs, 649

#### S

Safety bandsawing, 49 occupational safety and health, labs, 668–672 Sample, materialographic specimen, 8-9 Sawing bandsawing, 48-52 circular sawing, 48 hacksawing, 48 power hacksawing, 48 sectioning, 47-52 Scanning electron microscope (SEM), 558-559 Scanning probe microscopes (SPM), 558-561, 560-561 Scanning transmission electron microscope (STEM), 558 Scleroscope, 645 Section type, selection, sectioning, 14-15 Sectioning, 14-53, 15 abrasive cut-off machines, 36-43 abrasive cut-off wheels, 32-36 fracturing, 45

occupational safety and health, labs, 664 other methods, 45-53 preparation process, 10-11 sawing, 47-52 sectioning by melting, 46 selection, 14-15 shearing, 46-47 wet abrasive cutting, 15-32 wet abrasive cutting tips, 43-45 wire cutting, 52-53 Sectioning by melting, 46 electric discharge machining (EDM), 46 laser torching, 46 oxyacetylene torching, 46 plasma torching, 46 Selection, sectioning, 14-15 general studies or routine work, 14 reporting locations, 15 research studies, 14 section type, 14-15 study of failures, 14 Selection of preparation method, 6-7 artifacts of electrolytic polishing, 7 artifacts of mechanical polishing, 7 preparation methods, 7 Semiautomatic systems, polishing, 140-143 Semiconductors, specimen preparation, 288-291 Sharpening, automatic image analysis, 593-595 Shearing punching, 47 sectioning, 46-47 Si wafers, specimen preparation, 288-291 SiC fibers in Ti matrix, specimen preparation, 273-276 SiC wet grinding paper, 100-105 Silicon, specimen preparation, 288-291 Silicon carbide abrasive types, 18 grinding abrasives, 93

Silicon nitride, specimen preparation, 235 - 237Silicon oxide, specimen preparation, 241 Silver electrolytic polishing and etching, 469-470 specimen preparation, 409-412 Sintered carbides specimen material, 187 specimen preparation, 443-447 Slow consumable wheels precision cut-off, 35 storing, 36 truing and dressing, 34-35 use, 35 wheel dimensions, 35 wheel velocity, 35 Smoothing, automatic image analysis, 592-593 Soft grade, 20 Software, automatic image analysis, 616-617 Solder balls, specimen preparation, 295-298 Sorby, Henry Clifton, 5-6 Special methods hardness testing, 646 Specimen material, 179, 181-187 ceramics, 182 classification of materials, 181 coatings, 182-183 composites, 183 ferrous metals, 183-184 materialographic specimen, 8-9 mineralogical materials, 184 nonferrous metals, 184-186 organic materials, 186-187 polymers, 187 powder metals, 187 sintered carbides, 187 Specimen preparation, 179-180, 218-521 abbreviations, 221 acrylics, 436-439 aluminum, 352-356 aluminum alloys, 356-358 aluminum oxide, 238-240 anodized coatings, 247-251 antimony, 361-364

barium titanate, 241 beryllium, 365-367 bones, 427–430 boron carbide, 227–232 brass. 376-380 bronze, 376-380 calcium oxide, 241 capacitors, 298-300 carbonitrided steels, 339-342 cement clinker, 346-349 ceramic capacitors, 281-284 ceramic layers, 268-270 ceramic resistors, 281-284 ceramics, 232-235 cerium oxide, 241 chromium, 367-370 chromium carbide, 232-235 chromium oxide, 238-240 cobalt, 370-373 cobalt-based super alloys, 373-376 composites, 276-281 concrete, 346-349 consumables, 221 copper, 376-380 copper-bearing alloys, 380-383 CVD coatings, 247-251 diffusion coatings, 251-254 diodes, 281-284 electrolytic polishing and etching, 453-475 electrolytically deposited coatings, 251-254 EPDM polymers, 430-436 field metallography/ materialography, 475-476 galvanization, 251-254 generic methods, 219 germanium, 288-291 glasses, 244-247 gold, 384-387 gray cast iron, 315-318 high-alloy steels, 325-328 high carbon steels, 307-311 high-speed steels, 343-346 hot dip zinc coatings, 254-257 hydroxyapatite (HA) coating, 223-226 integrated circuits, 301-305

lead, 387-391 low-alloy steels, 336-339 low carbon steels, 311-314 magnesium, 391–394 magnesium oxide, 241 malleable cast iron, 315-318 manganese, 395-397 medium carbon steels, 307-311 microelectronic material, 291-293 microelectronic packages, 295-298, 301-305 minerals, ores, 349-352 molybdenum, 398-401 nickel, 402-405 nodular cast iron, 319-321 optical fibers, 244-247 paint layers, 257-260 palladium, 406-409 parameters, 220-221 PCB coupon, 305-307 plasma spray coatings, 265-267, 270-273 plated coatings, 251-254 powder metals, 439-443 PVD coatings, 247-251 quantitative metallography/ materialography, 567-568 resistors, 293-295 semiconductors, 288-291 Si wafers, 288-291 SiC fibers in Ti matrix, 273–276 silicon, 288-291 silicon nitride, 235-237 silicon oxide, 241 silver, 409-412 sintered carbides, 443-447 solder balls, 295-298 stainless steels, 328-333 steps, 219-220 super alloys, 333-335 teeth, 427-430 thermal spray coatings, 260-265 tin, 413–416 tin cubic boron nitride, 232-235 tissue, 427-430 titanium, 416-420 titanium carbide, 232-235 titanium nitride, 232-235

transistors, 301-305 trouble shooting, 476-521 tungsten carbide, 232–235 uranium, 447-450 white cast iron, 322-324 wrought aluminum alloys, 359-361 YBCO ceramic super conductors, 285-288 zinc, 420-423 zinc oxide, 241 zirconium, 424-427 zirconium dioxide, 241 Sprays, diamond products, 96 Sputtering, etching, 174 Stainless steels electrolytic polishing and etching, 460-461 specimen preparation, 328-333 Stamping, marking, 80 Standard Operating Procedure (SOP), 670-672 Standards, occupational safety and health, labs, 673 Static hardness testing, 626-643 Brinell hardness testing, 626-628 hardness values conversion, 642-643 hardness values precision, 642 instrumented indentation testing, 641-642 Knoop hardness testing, 633-634 microindentation hardness, 636-639 Rockwell hardness testing, 634-636 universal hardness, 639-642 Vickers hardness testing, 628-632 Step cutting, design principles of wheel, 38-39 Steps, specimen preparation, 219-220 Stereo microscopy, 555-557 Stereology, 565-567 Stones/disks, grinding, 99-100 Storage, 81 Storing consumable abrasive cut-off wheels, 33-34 slow consumable wheels, 36

Structure, cut-off wheel, 20 Study of failures, selection, sectioning, 14 Super alloys electrolytic polishing and etching, 461 specimen preparation, 333–335 Surface preparation, 11–13 Suspensions, diamond products, 96 Synthetic grinding fluids-oil-based, 26–27

# Т

Teeth, specimen preparation, 427-430 Testing and inspection labs, 651 Thermal damage, wet abrasive cutting, 23 - 25clamping, 24-25 wet cutting, 25 Thermal etching, 174 Thermal spray coatings, specimen preparation, 260-265 Thickness measurements, automatic image analysis, 608-610 Thin sections, polishing, 152–154 Tin electrolytic polishing and etching, 470-471 specimen preparation, 413-416 Tin cubic boron nitride, specimen preparation, 232–235 Tissue, specimen preparation, 427-430 Titanium electrolytic polishing and etching, 471 specimen preparation, 416-420 Titanium carbide, specimen preparation, 232-235 Titanium nitride, specimen preparation, 232-235 Toxic substances, occupational safety and health, labs, 666 Traditional grinding, 99-106 Traditional versus contemporary methods, specimen preparation, 218 Training, occupational safety and health, labs, 673

Transistors, specimen preparation, 301–305 Transmission electron microscope (TEM), 558 Trouble shooting, specimen preparation, 476–521 True microstructure, 5–6, 6 Truing and dressing cut-off wheel wear, wet abrasive cutting, 26 slow consumable wheels, 34–35 Tungsten, electrolytic polishing and etching, 472 Tungsten carbide, specimen preparation, 232–235

# U

Ultramilling, polishing, 155 Ultrasonic apparatuses cleaning, 83 Ultrasonic cleaning, 83 Universal hardness, static hardness testing, 639–642 Unplane surface, mechanical damage, wet abrasive cutting, 23 Uranium, specimen preparation, 447–450 Use, slow consumable wheels, 35

# V

Vanadium, electrolytic polishing and etching, 472–473 Vapor deposition, etching, 174 Vickers hardness testing, 628–632 Visible light, light microscopy, 525–526 Volume fraction automatic image analysis, 602–603 quantitative metallography/ materialography, 569

#### W

Water-based grinding/polishing fluids, 97 Water-oil based grinding/polishing fluids, 98

Water quality, cutting fluids, wet abrasive cutting, 28 Waterproof ink marking, 80 Watershed filter, automatic image analysis, 590–592 Waviness, mechanical damage, wet abrasive cutting, 23 Wet abrasive cutting, sectioning, 15-32 abrasives and bond materials, 16-21 cut-off grinding process, 15-16 cut-off wheel, 16-21 cut-off wheel wear, 25-26 cutting fluids, 26-29 grinding mechanics, 21–22 mechanical damage, 22-23 metallographic/materialographic cutting operation, 29–32 thermal damage, 23-25 tips, 43-45 Wet cutting, thermal damage, 25 Wheel dimensions consumable abrasive cut-off wheels, 33 slow consumable wheels, 35 Wheel velocity consumable abrasive cut-off wheels, 32-33 metallographic/materialographic cutting operation, 30

slow consumable wheels, 35 White cast iron, specimen preparation, 322–324 Wire cutting, 52–53 Wrought aluminum alloys, specimen preparation, 359–361

# Υ

YBCO ceramic super conductors, specimen preparation, 285–288

# Ζ

Zinc electrolytic polishing and etching, 473 specimen preparation, 420–423 Zinc oxide, specimen preparation, 241 Zirconia alumina wet grinding paper, 105–106 Zirconium electrolytic polishing and etching, 474 specimen preparation, 424–427 Zirconium dioxide, specimen preparation, 241