

Index

- AAS** *See* atomic absorption spectroscopy.
- adhesion of ceramic film 57–59
- aerosol generator 30–32
- AES *See* Auger electron spectroscopy.
- AFM *See* atomic force microscopy.
- agglomerates 4, 22–23, 140
- analysis bias 147, 148
- analytical scanning electron microscopy (ASEM) 105
- ASEM *See* analytical scanning electron microscopy.
- atomic absorption spectroscopy (AAS) 83, 132
- atomic force microscopy (AFM, also SFM) 48, 49, 142
- Auger electron spectroscopy (AES)
- bonding 53, 54
 - ceramic films 50
 - glass corrosion 112
 - glass surfaces 105, 106
 - lineshape depiction 53–54
 - sintered ceramics 91, 92
 - summary 269
- BET** 4, 112
- BET adsorption isotherms 149, 165
- C**
- Calibration of instruments 155
- CBED *See* convergent-beam electron diffraction.
- ceramic coatings *See* ceramic films.
- ceramic composites
- adhesion 201–202
 - flaws 198–199
 - fracture toughness 195–198
 - overview 189–191
 - permanent deformation 193–195
 - piezoelectricity 204
 - pyroelectricity 236–237
 - R-curve behavior 191–192
 - resistance to oxidation 202–203
 - voltage dependant conductivity 205–206
 - whisker reinforcement 189
- ceramic films
- adhesion 57–59
 - chemical characterization 50, 56–57
 - coatings 43–47
 - color 50
 - defects 60, 68, 126
 - density 3, 46, 66
 - hardness 59–60
 - stress 60, 66–67
 - surface finish 46, 47, 49–50
 - surface morphology 48
 - thickness 48–49
- ceramic grains 120–122, 172
- ceramic–metal interfaces 212–225
- ceramic powder production 29–38
- ceramic sensors 241–242
- ceramic thick films *See* thick films.
- chemical adsorption measurements 276
- chemical bonding 53–56
- chemical vapor deposition (CVD) 44, 45, 47
- chemical vapor infiltration (CVI) 197
- colorimetry 9
- color, film 50
- connectivity 122

consolidation of ceramics 78, 80
convergent-beam electron diffraction 132
cracks
 causes 169–170
 fatigue cracking 199
 features 174–178
 flaws 170–172
 growth direction 174–175
 hackle and mist 176–180
 velocity 175–176
cryo-TEM 16–18, 21
curvature 66–68
CVD *See* chemical vapor deposition.
CVI *See* chemical vapor infiltration.

Defects in ceramics 126–129, 171–172,
256–264

dehydration of ceramic body 79
delamination of film 60
densification 81–82, 92–94, 123
density in powders 149
Diamant–Pepinsky bridge 238
differential scanning calorimetry (DSC)
 phase measurements 149, 155, 164
 pre-sinter thermal process 90
 reactivity in ceramics 147
 solid–solid reaction rate 163
 transition temperature measurement 150
differential thermal analysis (DTA)
 phase measurements 147, 149, 155, 164
 precursor powders 4–5
 pre-sinter thermal process 90
 reactivity in ceramics 147
 sintered ceramics 91
 sintering behavior 69–70
 solid–solid reaction rate 163
 temperature of reaction 68
 transition temperature 150
dilatometer 69, 92
dilometry 90, 147
dislocations 127–129
domain boundary 124
DSC *See* differential scanning calorimetry.
DTA *See* differential thermal analysis.
DVLO theory 6–7

EDS *See* electron dispersive spectroscopy
EDX *See* energy dispersive X-rays.

EELS *See* electron energy loss spectroscopy.
EGA *See* evolved gas analysis.
elastic recoil detection (ERD) 52, 112
electron beam irradiation 51, 105
electron diffraction 56–57
electron dispersive spectroscopy (EDS)
 ceramic–metal interface 212
 determination of glass composition 192
 green ceramic compacts 83–84
 phase chemistry 132, 133
 sintered ceramics 92
 summary 272
electron energy loss spectroscopy (EELS) 92,
133, 270
electron microprobe 201
electron probe microanalysis (EPMA)
 ceramic films 51–52
 dielectricity 234
 heating of pyrochlore compounds 245
 interface profiles 212–213
 phase composition 130
 sintered ceramics 91
 summary 271
electron spectroscopy for chemical analysis
 (ESCA) 51
electron spin resonance 9
energy dispersive X-rays (EDX)
 anorthite in film 71–72
 ceramic thin films 51–52
 planar mapping 146
 reaction mechanisms 163
environmental scanning electron
 microscope 142, 165
epitaxy 125–126
EPMA *See* electron probe microanalysis.
ERD *See* elastic recoil detection.
ESCA *See* electron spectroscopy for chemical
 analysis.
ESEM *See* environmental scanning electron
 microscope.
ETA *See* emanation thermal analysis.
evolved gas analysis (EGA) 147
Ferrites (magnetic ceramics) 239–240
ferroelectric ceramics 237–238
films *See* ceramic films.
Fourier transform infrared spectroscopy
 (FTIR) 68, 90, 273
fractal geometry 15

fractography 182–187

FTIR *See* Fourier transform infrared spectroscopy.

Gas chromatography/mass spectra
(GC/MS) 68

GC/MS *See* gas chromatography/mass spectra.
glass

bonding 108–110

corrosion by water 111–114

corrosion layers 112–114

crystallization 114–115

flaw-induced breakage 172

fracture 174–181

sample preparation 108

static fatigue 173

surface analysis 105–108

transition metals in 106–107

glass–ceramics 114–115

glow discharge plasma 35–37

grain

boundary 124, 192, 200, 205, 234

ceramic breakage role 172

crack propagation 200

growth 2, 80–81, 121

shape 121–122

size 95, 134–135,

green body

fabrication 78–79

formation processes 5

physical characteristics 83–84

powder formed into 32

green ceramic compacts 79, 83–89

green density 66, 87, 88

Hard carbon coatings 46–47, 53

high resolution electron microscopy
(HREM) 225

high-temperature deposition 46

hot-stage X-ray diffraction 150

HREM *See* high-resolution electron
microscopy.

IBSCA 113

ICP *See* inductively coupled plasma
spectroscopy.

impurities 81, 83, 123

inductively coupled plasma (ICP)
spectroscopy 9, 83, 90

infrared (IR) spectroscopy 9, 55

infrared microscopy 262

insulators 231–234

interfaces 125–126, 223–225

ion beam glass surfaces 105–106

ion scattering spectroscopy (ISS) 91, 112

ISS *See* ion scattering spectroscopy.

Laser interferometry 236

laser reflectance 69

lattices 57, 129, 132, 263

LECO combustion analysis 68

light microscopy 274

lineshape 54–55

Magic-angle spinning-nuclear magnetic resonance (MAS-NMR) 112

magnetic ceramics (ferrites) 239–240

magnetic resonance imaging (MRI) 89, 147

magnetic resonance spectroscopy (MRS) 132,
147

MAS-NMR *See* magic-angle spinning-nuclear
magnetic resonance.

mercury intrusion porosimetry 4, 87

microindentation 59–60

microstructure of sintered ceramics 80

microtomography 199

MLC *See* multilayer ceramic.

Mossbauer spectroscopy 145

MRI *See* magnetic resonance imaging.

MRS *See* magnetic resonance spectroscopy.

multilayer ceramic (MLC) 64, 232

NMR *See* nuclear magnetic resonance.

NPB-SIMS *See* neutral primary beam-SIMS.

neutral primary beam-SIMS
(NPB-SIMS) 112

neutron diffraction 275

NRA *See* nuclear reaction analysis.

nuclear magnetic resonance (NMR)

local bonding 145

MAS-NMR 112

speciation 9

study of thin films 243

summary 282

nuclear reaction analysis (NRA) 113
nucleation 19–22

OM *See* optical microscopy.

optical microscopy (OM)
 crystalline material analysis 120
 green ceramic compacts 83
 morphology 4
 packing 83–85
 phase measurements 130–133, 141
 processing defects in glass 114
 shrinkage of films 69
 sintered ceramics 91
 thickness of films 65

PAM *See* photoacoustic microscopy.

particles
 growth 5, 8, 10–18, 22, 33, 35
 nucleation 19–22
 physical characteristics 3–4, 12, 160
 size characterization 12

phases

 bonding 144
 composition 132–133
 distribution 130
 equilibria 140–156
 quantification 133–134
 structure 131–132

photoacoustic microscopy (PAM) 262
physical adsorption measurements 276
physical vapor deposition (PVD) 44, 45, 48
piezoelectric effect 204, 234–236

pores, porosity

 ceramics 123
 porous compacts 89
 powder compacts 88
 powders 149
 shrinkage 81
 size 87–88

porosity *See* pores.

potentiometry 9

powder

 agglomerate properties 4
 characterization 3–7, 39
 chemical synthesis 2–3
 classification 3
 crystallization 4
 decomposition 4–5
 density 149

 morphology 32

 particle characteristics 3

 particle morphology 32, 39

 particles in precursor process 32

 physical characteristics 3–4

 plasma techniques 35–37

 porosity 149

 supercritical fluid techniques 37–39

 surface area 39

 synthesis 8, 30–33

 vapor precursor process 32–35

powdered compact 90–91

precursor powders *See* powders.

pre-sinter thermal processing 79

pressure sintering 94

profilometer 65, 67

pulse-reflection acoustic microscope 202

PVD *See* physical vapor deposition.

pycnometry 93

pyroelectric ceramics 236–237

Raman spectroscopy

 chemical bonding 55–56

 fatigue cracking 200

 local bonding 145

 silanol species 111

 speciation 9

 summary 277

rapid expansion of supercritical fluid solutions
 (RESS) 38

RBS *See* Rutherford backscattering
 spectroscopy.

reaction rates and mechanisms 156–166

RESS *See* rapid expansion of supercritical
 fluid solutions.

Rutherford backscattering spectroscopy (RBS)

 chemical characterization of films 52

 glass corrosion 111–113

 mass density 48

 summary 278

 thin films 247

SAED *See* selected area electron diffraction.

SAM *See* scanning acoustic microscopy.

SANS *See* small angle neutron scattering.

Sawyer–Tower circuit 238

- SAXS *See* small angle X-ray scattering.
- scanning acoustic microscopy (SAM) 50, 91, 122, 197
- scanning electron microscopy (SEM)
 absence of chemical reaction 202
 adhesion 58, 201
 advantages 142
 ceramic composite fibrous region 197
 ceramic-metal interface 212
 film thickness 49
 fractures 182, 200
 grain sampling 134
 grain size 48
 green ceramic compacts 83
 growth mode 48
 interface structures 202
 mapping 146, 203
 microstructures 71, 203
 nucleation 19
 oxide layer thickness 195
 particle morphology 4, 48
 phase measurements 130, 133, 142
 sintered ceramics 91, 94
 sintered thick films 73-74
 sintering behavior 69-70
 sol-gel 247
 submicron boundaries 130
 summary 279
 surface height changes 130
 voids and pores 47, 202-203
- scanning force microscopy (SFM) *See* atomic force microscopy.
- scanning laser acoustic microscopy (SLAM) 260
- scanning transmission electron microscopy (STEM) 73, 92, 280
- scanning tunneling microscopy (STM)
 electrical properties 206
 film thickness 49
 structure 206
 summary 281
 surface morphology 48, 142
- screen printing 64
- secondary ion mass spectrometry (SIMS)
 chemical characteristics of films 51, 52
 chemistry of AlN substrates 72
 chemistry of sintered ceramics 91
 fabrication of thin films 247
 glass surfaces 106
 NPB-SIMS 112
- selected area electron diffraction (SAED) 244
- SEM *See* scanning electron microscopy.
- sensors 241-242
- SFM *See* atomic force microscopy.
- SIMS *See* secondary ion mass spectrometry.
- sink-float method 93
- sintered ceramics 90-95
- sintering 80, 81, 90, 94
- sintering shrinkage 68-70
- SIPS 113
- SLAM *See* scanning laser acoustic microscopy.
- small angle neutron scattering (SANS) 16, 89, 95
- small angle X-ray scattering (SAXS) 16, 89, 95
- sol-gel 8-9, 45-46, 247
- solutions of precursor materials 31
- speciation 8-10
- spectra lineshapes 54-55
- spray pyrolysis 31-33
- SQUID magnetometer 239
- SQUID (superconducting quantum interference device) 239
- stacking faults 126-127
- STEM *See* scanning transmission electron microscopy.
- STM *See* scanning tunneling microscopy.
- strength of ceramics 169-171
- stress in thick films 65-68
- submicron powder formation 38
- substrate curvature 66-68
- superconduction 238-239
- supercritical fluids 37-38
- supersaturation 8-12
- T**ape casting 5, 64, 68
- TEM *See* transmission electron microscopy.
- TG *See* thermogravimetry.
- TGA *See* thermogravimetric analysis.
- thermal decomposition 30-35
- thermal discharge plasma 35-37
- thermocouples 155
- thermodilatometry 149
- thermogravimetric analysis (TGA) 4-5, 68, 90
- thermogravimetry (TG)
 calcination temperature 138
 composition analysis 152

- thermogravimetry (TG) (*continued*)
 - magnetic transitions 155
 - phase equilibria 151
 - reactivity 147
 - temperature measurements 154
 - weight gains 165
- thermomechanical analysis (TMA) 90, 92
- thermomagnitrometry (TM) 155
- thick films
 - low- and high-temperature processing 68
 - processing 64
 - shrinkage 68–70
 - stress 65–70
- thin films
 - device preparation 247–248
 - electrical properties 243–244
 - electric stack 248–249
 - ferroelectric films 242–243
 - pyrochlore compounds 245–247
 - structural evolution 243
- TM *See* thermomagnitrometry.
- TMA *See* thermomechanical analysis.
- transition metals in glass 106
- transmission electron microscopy (TEM)
 - absence of chemical reaction 202
 - adhesion 201
 - atomic structure 131
 - boundary phase 200
 - ceramic–metal reactions 73–74
 - defect in boundaries 129
 - epitaxial growth 126
 - facet imaging 125
 - grain measurements 121, 134
 - interface imaging 143, 213, 224
 - microstructure 71, 203
 - nucleation 19, 21
 - particle morphology 4, 48, 133, 142
 - particle size 22
 - phase measurements 130, 132
 - R-curve behavior 192
 - reinforced composite behavior 193, 194
 - sintering behavior 70
 - stacking faults 126
 - summary 284
 - thickness of film 49
 - thin films 243
 - voids and pores 47
- traveling microscope 69
- Ultracentrifugation 9
- ultrasonic disruption 4
- ultraviolet photoelectron spectroscopy (UPS) 91
- UPS *See* ultraviolet photoelectron spectroscopy.
- Vapor precursor process 33–35
- vapor transport 44
- variable angle spectroscopic ellipsometry 285
- VASE *See* variable angle spectroscopic ellipsometry.
- VLSI (very large scale integration) 232
- Wavelength dispersive spectroscopy (WDS) 83, 133
- wavelength dispersive X-rays (WDX) 51–52
- WDS *See* wavelength dispersive spectroscopy.
- wetting of interfaces 219–225
- XIPS *See* X-ray photoelectron spectroscopy.
- X-ray diffraction (XRD)
 - angle of peak radiation 264
 - crystal structure 131, 150
 - dielectric properties 237
 - glass crystallization 115
 - grain size 95
 - green ceramic compacts 83
 - microstructure 56–57, 203
 - phase measurements 133, 144, 145, 203
 - poling 204–205
 - sintered ceramics 90, 91
 - sintered films 70–71
 - sintering behavior 69–70
 - solid–solid reactions 163
 - starting material chemistry 203
 - stress 66, 263, 264
 - structure of precipitates 5
 - sublayer chemistry 203
 - substrate curvature 67
 - summary 286
- X-ray fluorescence spectroscopy (XRF)
 - chemical characterization of films 51–52
 - green ceramic compacts 83

- phase chemistry 132
- sintered ceramic composition 90
- summary 287
- X-ray Laue patterns 131
- X-ray photoelectron spectroscopy (XPS)
 - chemical bonding in films 53
 - chemical characterization of films 51
 - glass corrosion 112
 - glass surfaces 106
 - F-bonds in glass 110
- fracture toughness 197
- sintered ceramics 91
- summary 288
- Ti-AlN interfaces in brazing 223–224
- valences of reaction products 213
- XRD *See* X-ray diffraction.
- XRF *See* X-ray fluorescence.
- Z**eta potential 7–8