

## Index

### a

- A-atoms tetrahedral sites 235  
 AB<sub>2</sub>O<sub>4</sub> 234  
 AB<sub>2</sub>O<sub>4</sub> spinel 235  
 AB<sub>2</sub>O<sub>6</sub> 130, 150  
 AB<sub>2</sub>O<sub>6</sub> barium strontium niobate  
   Ba<sub>5x</sub>Sr<sub>5</sub> 140  
 Ablation particles 54  
 ABO<sub>3</sub> (barium titanate) 18, 82, 126,  
   140, 149, 225, 235  
 ABO<sub>3</sub>Pb 103  
 Abrahams, S.C. 151  
 Abrikosov, Alexi A. 18  
 Absorption of high energy electron  
   beam heats 63  
 Acceptors Group III elements 158  
   acidic-alkaline 220  
 AC/DC 185  
 Acoustical amplifiers and  
   acousto-optical devices 221  
 Acousto-optic materials 254  
   active ferroelectric STN 139  
 AC power source 194  
 AC power supply 136  
 AC signal 108, 112–16  
 AC source 135, 187  
 AC supply 112, 185  
 actuators, micromachined PZT 117  
 AC voltage 108, 112  
 AFC (alkaline fuel cell) 224  
 AFE 141  
 AFE phase 141  
 AFM (atomic force microscope) 57,  
   68–71, 106, 108, 112, 117  
   image 69  
   imaging 69  
   probe 69  
 AFQjCNHekD116tBBdx8ycrQ1z-  
   Eo6LVkk1Q&ust 47  
 Ag 2, 5, 9, 27, 154, 176–78, 196, 216,  
   230  
   antimony sulfo-iodide 140  
   Antiferromagnetic and ferroelectric  
     effects 103  
   Antimony-sulfo-iodide 148  
   Antiparallel configuration of domains  
     237  
   Appendix 257, 259, 261, 263  
   Appendix II 164  
   Applications of ferroelectricity 151  
   Applications of multiferroics 95, 105  
   Applications of PTC and NTC  
     thermistors 209  
   Applications of Pyroelectricity 146  
   Applied Chemistry 42  
   Applied Superconductivity 31  
   Ar 16–17, 35, 48, 52, 75, 230, 240  
   Ar Krypton 16  
   Arrhenius equation 210  
   Arsenic 158  
   Ar SiO 52  
   Ashcroft, N.W. 31  
   assistants Walter Friedrich 61  
   associated issues 95, 103  
     asymptotic 134  
   Atalia, M.M. 213  
   ATO acts 183  
   ATO layer by RF magnetron sputtering  
     183  
   Atomic and nuclear physics 25  
   Atomic Force Microscope *see* AFM  
     (atomic force microscope)  
   Atomic plane 60–61  
   atoms, body diagonal Ti<sup>4+</sup> 127  
   ATO SnO<sub>2</sub> 183  
   A-type cations 130  
   Au/Al 176  
   Aufbau 238  
   Aufbau principle 238  
   Auger electrons 64  
   Auger surface analyzer 63  
   Augustin, Charles 73  
 Ag/Al 176  
 AgI<sub>2</sub> 224  
 Ag/Si contact 178  
 Ainger 151  
 airflow 221  
 Akasaki, Isamu 181  
 Akbar, S.A. 213  
 Alabama xiii–xiv, 46, 120  
   Albert Einstein 1, 8, 33, 57, 240  
 AlGaInP/GaAs 181  
 AlGaN 182, 212  
 AlN 113, 154  
 Al<sub>2</sub>O<sub>3</sub>, xiii 41, 53, 75, 154, 183  
 Al<sub>2</sub>O<sub>3</sub> Trigonal 250  
 AlPO<sub>4</sub> 53  
 Al/Si 178–79  
 Al/Si contact 178–79  
 Aluminum 2, 5, 9, 17, 158, 166, 218,  
   231–32  
   gallium nitride UV 182  
   oxide Al<sub>2</sub>O<sub>3</sub> 231  
   X-rays 67  
 Amano, Hiroshi 181  
 American Ceramic Society xiv, 1, 33,  
   35, 57, 73, 95, 121, 153, 173, 247,  
   257, 259, 261, 263  
 American mathematician 149  
 American Physical Chemist 8  
 American physicist Peter 103  
 American Physicists 12, 19  
 Amperé's law 14  
 Amsterdam 150  
   ancient 229  
 Anderson, Phillip 23  
 Anisotropy 76, 93, 120, 129  
 Anomalous PV 222  
   anomalous 169–70, 222  
 Antennas 240  
 Antiferroelectric energy storage 225  
   antiferroelectric 102, 141–42  
 Anti-ferromagnetic Cr<sub>2</sub>O<sub>3</sub> 103

- Augustin-Jean Fresnel 249  
 Au/Si contact 178  
 Austenite 38  
 Austria 12, 14  
 Austrian Physicist Christian Doppler 118  
 Average frequency 180  
 Average photon energy 180  
 Avogadro's number 27, 86, 236, 259  
 Axial and angular-based definitions of crystal classes 79  
 Azad, A.M. 213  
 Azaroff, L.V. 15, 31
- b**
- Ba (barium) 18, 127–28, 231, 235, 237–38  
 Ba Radium 16  
 $Ba_{1-x}Sr_x$  147  
 $Ba_2$  127  
 $Ba^{2+}$  ions occupy 127  
 $Ba_2Sr_3Nb10O_{30}$  130–31  
 $Ba_4$  130  
 Ba-based fluorides 103  
 $BaCoF_4$  123  
 $BA_{eff}$  237–38  
 $BaFeF_4$  103, 123  
 $BaFe_{12}O_{19}$  233  
 Ba-ferrite 233  
 Ba-ferrite Hard Ceramic 239  
 Balmer series 10  
 $BaMnF_4$  103  
 $BaNbO_3$  130  
 Banerjee, S. 171  
 $BaNiF_4$  103, 123  
 Bardeen, John 18, 19, 23, 29, 190  
 Barium oxide ( $BaO$ ) 50, 231  
 Barium strontium titanate  $Ba_xSr_{1-x}TiO_3$  140  
 Barium titanate ( $BaTiO_3$ ) 52, 66, 107, 111, 123, 125–26, 128–29, 131, 137–38, 141–42, 148–49, 207–8, 218, 221, 223, 251  
 Barium titanate domains 138  
 Barquinha, P. 213  
 Barrier height ( $\Phi_0$ ) 188  
 Barrier height, lowest Schottky 179  
 Barthélemy 120, 242, 245 based 194, 204  
 Bartholm, Rasmus 249  
 Basic concepts 33  
 Basic crystallographic properties of cubic crystals 85  
 Basic crystal structures 73, 77  
 Basic experimental configuration of scanning force microscopes 68  
 Basic formula 232  
 Basic formulations 103  
 Ba-Sr-niobate series 130  
 $BaTiO_3$  36, 51, 66, 75, 82, 89, 107, 114, 123, 126–28, 140–41, 149, 207, 221, 223  
 $BaTiO_3$   $LiNbO_3$   $LiTaO_3$   $Pb_{1-x}$  111  
 $BaTiO_3$  unit cell 127  
 batteries and fuel cells 224  
 Battery-supercapacitor 220  
 Battery-supercapacitor hybrid (BSH) 220  
 Battery systems for electrically powered vehicles 228  
 $Ba_xSr_{5-x}Nb_{10}O_{30}$  130  
 BCSCO 18  
 BCS theory 19, 23  
 BCS theory of superconductivity 18  
 Becquerel, A.E. 222  
 Bednorz, Georg 18  
 Bell Laboratories 44, 47, 51, 190, 198  
 Bell Telephone Laboratories 213  
 Beratan, H.R. 55  
 Berkeley 103  
 Bernstein, J.L. 151  
 Beryllium 16  
 Betzig, Eric 59  
 B-fields 248  
 BFO 61–62, 104  
 BFO film 67, 70  
 BFO for bismuth ferrite 104  
 Bhalla, A.S. 151  
 Bi 15, 67, 99  
 Biard, R. 160, 171, 181, 213  
 Biaxial crystals 249  
 Bi-based perovskite 227  
 Bibes, M. 120, 242, 245  
 $Bi_2CaSr_2Cu_2O_8$  18  
 $Bi_2Ca_2Sr_2Cu_3O_{10}$  18  
 $Bi_4f$  of Bismuth ferrite film 67  
 $BiFeO_3$  103–4, 223  
 $BiFeO_3$  Bismuth 242  
 $BiFeO_3/CoFeB$  bilayer 242  
 $BiFeO_3$  Perovskite 141  
 $Bi_4Ge_3O_{12}$  54  
 $BiMnO_3$  103  
 Binary phase diagrams 35  
 Binding energy of electrons 67  
 Binding forces in solids 73  
 Binding forces in solids and essential elements of crystallography 73, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93  
 Binning Gerd 68  
 $Bi_2O_3$  186  
 Biodiesel 216  
 Biopower generation Hydropower Wind 216  
 Biosensors 241  
 bipolar junction transistor *see* BJT (bipolar junction transistor)  
 Birefringence crystals 254  
 Birefringence  $\Delta n$  249  
 Bismuth silicate  $Bi_{12}SiO_{20}$  251  
 $Bi_4Ti_3O_{12}$  140  
 BJT (bipolar junction transistor) 51, 190, 193, 195–96, 212  
 BJT, classical solid-state 193  
 BJT devices 193, 196  
 BJT transistor 195–96  
 Bloch, Felix 28  
 BNdFeO 227  
 BNT 141  
 Bohr, Niels 10–11  
 Bohr designations 14–15  
 Bohr magnetron 24, 236, 238, 242, 259  
 Bohr's model of hydrogen atom 10–11  
 Bohr's Theory 7, 11  
 Bohr's Theory of Hydrogen Atom 10  
 Boltzmann, Ludwig 24  
 Boltzmann constant 6, 25, 155, 164, 178, 259  
 Boltzmann statistics 24, 155  
 Bonded  $H_2$  74  
 Borchardt-Ott, W. 79, 93  
 Born, Max 12  
 Boron 17, 158  
 Bose-Einstein distribution function 25  
 Bottom electrode 114, 117, 138, 222–23, 252  
 Bragg angle 253, 255  
 Bragg condition 62, 71  
 Bragg diffraction 71, 253  
 Bragg diffraction angle 71  
 Braggs William and Lawrence 60  
 Bragg's equation 253  
 Bragg's law 60–62  
 Bragg's law of XRD 61  
 Brattain, Walter 190  
 Braun, Wernher von 173  
 Bravais, Auguste 78

- Bravais lattice Order of symmetry 79  
 Bravais lattices 78–79, 86–89, 91–92  
 Brenner, S. E. 55  
 Brewster 143  
 Brian, D. 18  
 Brian David Josephson 22, 29  
 Brian 22  
 Bridgman 34, 54  
 brilliant 29  
 Brillouin, Léon Nicolas 28–29, 253  
 Brillouin zones 28–29, 81  
 British mineralogist 80  
 British physicist 188  
 Broglie, Louis de 11–12, 22, 29, 63  
 Broglie Hypothesis 11, 63  
 Broglie of France 11, 29  
 Broglie principle 7  
 Broglie relationship 12, 59, 160  
 Broglie wavelength 30  
 Brookhaven National Labs 191  
 Brophy, J.J. 15, 31  
 BSH (Battery-Supercapacitor Hybrid) 220  
 BST 140, 147  
 BT *see* barium titanate ( $\text{BaTiO}_3$ )  
 BT  $\text{BaTiO}_3$  131  
 BT crystal lattice 66  
 BT layer 66  
 BTO 104  
 BTO capacitors 140  
 BTO/CFO 104  
 BTO electro-optics 140  
 BTO/LMO 104  
 BT thermistor 207  
 B-type cations occupy 130  
 Buchanan, R.C. 213  
 Bulk  $\text{BiFeO}_3$  103  
 Bulk PV effect 222  
 Bulk PZT actuator 112  
 Byer, R.L. 145, 151
- C**  
 Ca atoms 82  
 $\text{CaCO}_3$  55  
 $\text{CaCu}_3\text{Ti}_4\text{O}_{12}$  55, 180, 196, 220  
 Ca-Cu-titanate 220  
 Cadmium 17  
 Cadmium telluride  $\text{CdTe}$  251  
 $\text{CaF}_2$  41, 54  
 $\text{Ca}_2\text{FeReO}_6$  242  
 $\text{Ca}^{2+}$  ions occupy 127  
 Ca Strontium 16  
 Calcine ball 39  
 Calcite  $\text{CaCO}_3$  Trigonal 250  
 $\text{CaO}$  41  
 Capacitance  $C_1$  187  
 Capacitance measurement 136  
 Carbon dioxide  $\text{CO}_2$  35  
 Carr, W. N. 213  
 Carver Company 40  
 Ca-Sr-Co-oxide ( $\text{Ca}_{0.4}\text{Sr}_{0.6}\text{CoO}_3$ ) 209  
 $\text{CaTiO}_3$  82, 92, 127, 149  
 $\text{CaTiO}_3$  crystal 249  
 $\text{CaTiO}_3$  lattice constant 92  
 $\text{CaTiO}_3$  structure 127  
 $\text{CaTiO}_3$  unit cell 127  
 Ca-Zr-In-oxide 209  
 CB *see* Conduction band (CB)  
 CCTO 66, 180, 196–98, 220  
 CCTO capacitor 198, 220  
 CCTO gate 196  
 CCTO gate oxide 197  
 CCTO supercapacitor 225  
 CCTO supercapacitor material 220  
 CCVS (constant current voltage supply) 194, 198, 212  
 CCVS and transconductance amplifiers 194  
 Cd 17, 86, 216, 234  
 CdA 137  
 Cd/A 137  
 $\text{Cd}_2\text{FeNbO}_6$  123  
 $\text{CdFe}_2\text{O}_4$  235  
 Cd-ferrite 235  
 $\text{CdO}$  179  
 $\text{CdS}$  17, 84, 116, 154, 167  
 $\text{CdSe}$  17  
 $\text{CdTe}$  17, 90  
 $\text{CeF}_2$  54  
 Centrosymmetric, symmetry symbol  
 Pyroelectric Piezoelectric 91  
 Centrosymmetric and  
 Noncentrosymmetric Crystals 87  
 Ceramics and single crystals of  
 piezoelectric materials 114  
 Cesium 141  
 Ceylon 143  
 Ceylon magnet 143  
 CFO 104  
 CGS 232  
 CGS system 231  
 CGS system of units 243  
 $\text{CH}_4$  74  
 Chang, Kai 150, 255  
 Change in resistance 204  
 Characteristic symmetry 250  
 Chemical formula  $\text{SiO}_2$  111  
 Chemical pollutants 215  
 Chen, L.H. 245  
 Cheong, S.-W. 120  
 China 203, 222, 229  
 Chromium 17  
 CiG 187  
 Cl 82  
 Cl- ions 82  
 CIP (Cold Isostatic Pressing) 41  
 CIP methods 41  
 Classical applications 240  
 classical Newtonian 160  
 of Ferrites 229, 239  
 Cl-ions 74  
 Clive Randall 42  
 CMOS processing 112  
 CMR 104, 239, 241  
 CMR effect and perovskite structure 241  
 CMR effects 239, 241–42  
 CMR materials 240–41  
 Cn 85  
 Co 6, 16, 28, 52, 86, 101, 107, 209, 230–31, 234, 239–40, 244  
 $\text{CO}_2$  40, 46, 209  
 Co Cr Cu Fe 216  
 Co Cr Cu Fe Mg 216  
 Coercive point  $H_c$  232  
 $\text{CoFe}_2\text{O}_4$  104, 233, 235  
 $\text{Co}_{0.8}\text{Fe}_{2.2}\text{O}_4$  107  
 Co-ferrite 233, 235  
 Co-ferrite hard magnetic recording 239  
 $\text{CO}_2$  gas 41  
 Cold Isostatic Pressing *see* CIP (Cold Isostatic Pressing)  
 Columbian interaction 68  
 Common examples of electrolytes 224  
 Comparative representation of  
 insulators 3  
 Comparison of refraction index and  
 permittivity 7  
 Compiled 156, 167  
 Components V1 136  
 Composite Table 90  
 Composition  $\text{A}_{0.2}\text{B}_{0.8}$  55  
 Composition  $\text{A}_{0.5}\text{B}_{0.5}$  37  
 Composition  $L_1$  36  
 Composition  $S_1$  36  
 Compositions  $\text{A}_{1-x}\text{B}_x$  35

- Computer-controlled growth process 52
- Concentration molecular 54
- Conditions for ohmic and nonohmic 178
- Conduction band (CB) 2–3, 25, 29, 154–60, 162, 170–71, 175, 188
- Configuration for circuit protection 185
- Configuration for measurement of sample resistance 163
- Configuration of micromachined device for energy harvesting 222
- Co nickel 17
- Constant current voltage supply *see* CCVS (constant current voltage supply)
- Constitutive equations for piezoelectricity 110
- Contact potential 178, 212
- Controlled melting 54
- conventional MOSFET 196
- conventional semiconductor 199
- Conventional-Microscope 71
- Converse PE-effect 114
- CoO 179
- CoO<sub>2</sub> 186
- Cooper, Leon N. 18, 19, 23, 29
- Cooper pairs 19, 23, 29
- Cooper pairs breaks 23
- Cooper pairs wander 23
- Cooper pair tunneling 23
- Corak, W.S. 213
- Correspondence of spectral series 14
- Costello, Lacy 214
- Co-TiO<sub>2</sub> 242
- Coulomb 24, 73, 263
- Coulombian force 73
- Coulomb interactions 24
- Coulomb's constant 73
- Coulomb's law 73
- Coupled dielectric phenomena xiv
- Coupled nonlinear effects in electroceramics 121, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 147, 149
- Coupled pyroelectric 122
- Courtesy of electroceramics Lab 40
- Courtesy of Electronic Materials Laboratory 41, 46
- Courtesy of Encyclopedia Britannica 65
- Courtesy of Texas Instruments 51
- Cr 5, 16, 86, 177, 230, 234, 244
- CRC Press 55
- Cr Manganese 17
- Cr<sub>2</sub>O<sub>3</sub> 103–4, 186
- CrO<sub>2</sub> Chromium 242
- CRT 209
- Crucible shaft 52
- Crucible susceptor 52
- Crystallize, ferroelectric BaTiO<sub>3</sub> 83
- Crystallographers, brilliant French 78
- Crystallographic considerations for piezoelectricity 108
- Crystal structure above TC Below TC 131
- Crystal structure dependence of polar axis in barium titanate 129
- Crystal system 91
- Cs 75, 131
- CsCrW<sub>4</sub> 103
- CSD-prepared PZT films 120
- Cs Francium 16
- CsPbCl<sub>3</sub> 141
- Cu 2, 5, 9, 17–18, 27, 59, 66–67, 86, 154, 178, 230–31, 234, 244
- Cu/Al 176
- Cu Auger 67
- Cu<sub>2</sub>O 155, 179
- Cu<sub>2</sub>O<sub>3</sub> 186
- Cubic Close-packed Structures 73, 85
- Cubic SrTiO<sub>3</sub> 40
- Cubic Triclinic Tetragonal Hexagonal Monoclinic Orthorhombic Trigonal 109
- CuO 18, 55, 102
- Cuprous oxide 179
- Curie 20, 125–26, 132–34, 139, 142, 234, 244
- Curie brothers 220
- Curie constant 126, 134, 234, 244
- Curie point 34, 102, 123–29, 133–35, 139–42, 148–49, 207, 231, 234, 236–37, 242–43
- Curie temperature 20, 125–26, 131–32, 134, 149, 234, 242–43
- Curie temperature and transition point 148
- Curie temperature of ferro-magnetic materials 238
- Cu/Si contact 178
- CuSO<sub>4.5</sub> H<sub>2</sub>O 54
- Cz-growth 52
- Cz-growth chamber 52
- Cz-growth experiment 51
- Cz-growth method 52
- Cz-growth systems 52
- Cz-method 51–52
- Czochralski, Jan 34, 51
- Czochralski crystal growth method 49
- Czochralski crystal growth technique 51
- Czochralski growth 54, 63
- Czochralski growth method 51
- Czochralski method 51
- Cz-technique 51–52
- d**
- Dallas 51, 213
- Dalton's law of partial pressure 211
- Danish physicist 10
- DARPA 220
- Datta, S. 213, 241, 245
- Davisson, Clinton 12
- DC (direct current) 23–24, 108, 113, 177, 185
- DC offset 145
- DC power source 194
- DC/RF power supply 48
- Debye, Peter J. 103, 253
- Debye temperature 5
- Defense Advanced Research Project Agency (DARPA) 220
- Defining parameters 77, 215, 217
- Defining properties of solids 1
- Dekker, Merkel 213
- Delin, K.A. 18, 31
- Demjanovic, D. 151
- Denmark 249
- Density of states and fermi energy 161
- Determination of bandgap 164
- Determination of contact potential and depletion width 178
- Determination of direct and indirect bandgap 166
- Determination of mobility 166
- Determination of radiation hardness of IHC 190
- Determination of resistivity 162
- Deuterated TGS 147
- Deutsches Museum 65
- Devonshire 130
- Devonshire Mean Field Theory of Ferroelectricity 121, 130

- Dielectric Phenomena in Solids 120, 150, 228
- Digital displacement transducers  
electrocaloric 122
- Dimensionless 232
- Dirac, Paul 24
- Direct and indirect bandgap 159, 166
- Direct band-to-band transition 159
- Direct current *see* DC (direct current)
- Direct infrared 167
- direct PE-effect 114
- Direct Potentially 167  
dispersive 57, 71
- Dissertation 71, 120
- DOE 237
- Domain configuration 137, 237
- Domain wall 126, 138, 236–37
- Dominant forces 95
- Dominant forces and effects in  
electroceramics 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 119
- Dong, L. 214
- Donors Group 158
- Doped BT 207
- Doped lead-zirconate-titanate 227
- Doped LSTO 242
- Doped  $Mn_3O_4$  207
- Doped p-GaAs 181  
doped 186
- Doping Group IV semiconductors 17
- Doppler effect 115, 118
- Doppler shift 118  
double-layered low-voltage 186
- Double-sided PZT films 120
- Dransfeld, K. 69, 71
- Ducharme, S. 151
- Dutch merchants 143
- Dynasty, Han 229
- e**
- ECSA 71
- EDAX 57, 65–66
- EDAX energy 34, 71
- Edward, J.S. 145, 151
- Edwin Powell Hubble 229  
Edwin 168
- E-FET 191, 196–97, 212
- E-FET device 196, 198
- E-FET transistor 197–99
- Effect and associated issues 95, 103
- Effect of Nb doping on pyroelectric property 151
- Effusion cell 47–48
- E-field 197
- E-field oscillation 248
- EFM 175
- EFS 176
- Egashira, M. 214
- Einstein, Albert 8, 11
- Einstein's equation of electron emissivity 8
- Einstein's matter 11
- Einstein's photoelectric effect 7
- Electrical conductance 1
- Electrical conduction in semiconductors 153
- Electrically Powered Vehicles 228
- Electrical properties 31, 171, 214, 245, 255, 261, 263
- Electric field dependence of polarization of pyroelectric material 144
- Electric field EC 176
- Electric field EEC 167
- Electric field tuned varistor 196
- Electric flux density 263
- Electric polarization reversal and memory 120
- Electroceramic magnetics 229, 231, 233, 235, 237, 239, 241, 243, 245
- Electroceramics xiii–xiv, 1–2, 6–8, 16, 18–20, 33–55, 57–58, 73–74, 95–151, 153–54, 173–74, 192–94, 214–18, 228–30, 247–48
- Electroceramics and green energy 215–227
- Electroceramic semiconductor devices 173–213  
electroceramic 199
- Electroceramics Lab 40
- Electromechanical 221
- Electron and hole motilities 168
- Electron-camera 47
- Electron devices 245
- Electron devices Soc 213
- Electronic analog 213, 245
- Electronic materials and devices 31, 245, 255
- Electronic Materials Laboratory 21, 40, 41, 46
- Electronic processes in materials 31
- Electro-optic deflectors 252
- Electro-optic modulators 213, 245, 252
- Electrothermal effects 96, 98, 144
- Element Li, third 16
- Elements Atomic number 158
- Elements Carbon 17
- Elements of group VIII 16
- Element titanium 17
- Embedded H-FET transistors 201–2
- Embedded magnetic field effect transistor 198
- Embedded voltage biased transistor 190  
embedded 194, 196, 198, 200
- Emitted radiance 182
- Emitting diodes lasers 154
- Emitting UV 44  
emitting 181
- Encyclopedia 150, 255
- Encyclopedia Britannica 65, 71
- Energies of X-rays 59
- Energy bands in semiconductors 153, 155
- Energy Enx 161
- Energy-hungry countries 222
- Energy industry 228
- Engineering materials 171  
Enrico 24
- Equilibrium phase diagram 33
- Eremetes, Mikhail 19
- Ergebnisse 120
- $ErMnO_3$  103
- Ernest 10  
Ernst 63  
Erwin 12
- Esaki, Leo 18, 22
- ESCA 57, 66–67
- ESCA (Electron spectroscopy for chemical analysis) 71
- Essential elements xiv, 26, 28, 153
- Essential elements of quantum mechanics 1, 7
- Essential theoretical concepts 229, 235
- Europe 143
- Europeans 143
- Evans Library xiv
- Ewald, Paul Peter 81  
Paul 24
- Ewen, R. J. 214
- Examples of donors and acceptors 158
- Examples of transparent binary metal-oxide semiconductor group 179
- Excimer lasers emit UV radiation 44
- Expanded piezoelectric zone 97
- Expanded pyroelectric zone 98

- Experimental determination 104, 121, 134, 137, 153, 162
- Experimental determination of piezoelectric coefficients 95, 111
- Experimental determination of pyroelectric coefficient 145
- Experimental setup for measurement of pyroelectric 146
- Experimental setup for monitoring photovoltaic effect 223
- Extrinsic n-type 174
- Extrinsic p-type 174
- f**
- Farad 263
- Faraday, Michael 207
- Faraday's law 19, 239
- Fatuzo, E. 125, 150
- F-D-distribution function 24
- F-D-statistics 24
- Fe 5, 9, 16, 86, 101, 106–7, 141, 191, 216, 223, 230–31, 234, 237, 239–40, 243–44
- Fe amounts 239
- Fe Cobalt 17
- Fe/Cr superlattices 241
- Fe Mn Pb 216
- Fe<sub>0.5</sub>Nb<sub>0.5</sub> 103
- Fe<sub>0.5</sub>Ta 103
- FE to ferroelectric and PE 141
- Fe<sup>2+</sup> 242
- Fe<sub>2</sub>O<sub>3</sub> 191, 229–30, 234–35
- Fe<sub>3</sub>O<sub>4</sub> 53, 101, 107, 203, 207, 229–30, 234–35, 243
- Fe<sub>3</sub>O<sub>4</sub> magnetite 242
- Fe<sub>2</sub>TiO<sub>5</sub> 46, 51, 180, 191
- Fe<sub>2</sub>TiO<sub>12</sub> 180
- Fe<sup>3+</sup> ions 242
- FE-AFM 106
- FE-AFM layer 106
- FE-FM Heterostructures  
Electro-optical device 122
- FeO 102, 179, 229, 235, 237
- Fe-PV 222
- Fe-PV devices 224
- Fe-PV effect 222–23
- Fe-PV materials, new 224
- Fe-PV solar cells and piezoelectric power generator 225
- FeRAM 105, 139, 149–50
- FeRAM devices 141
- FeRAM structure, based 138
- FeRAM technology 141
- Fermi, Enrico 1–2, 24, 26, 30, 155
- Fermi-Dirac distribution plot 26
- Fermi-Dirac distribution 155
- Fermi-Dirac distribution function 1–2, 24
- Fermi-Dirac statistics 30, 154–55
- Fermi-Dirac statistics merges 155
- Fermi energy 3, 25–27, 29–30, 155–56, 161–62, 167, 170–71
- Fermi function 25–26, 155
- Fermi level 3, 25, 29, 155–56, 164, 170–71, 174–75, 188
- Fermi level changes 29
- Fermi levels merge 175
- Fermi momentum 26
- Fermi temperature  $T_F$  26–27
- Fermi velocity 21, 26–27
- Ferroelectric 120
- Ferroelectric and ferromagnetic coupled memory 105
- Ferroelectric and ferromagnetic effect 103
- Ferroelectric Crystals 89, 124, 126, 136, 151
- ferroelectric Curie point 103, 145
- ferroelectric Curie temperature 207
- Ferroelectric parameters 121, 125, 134
- Ferroelectric photovoltaic devices 222, 228
- Ferroelectric/Piezoelectric layer 104  
ferroelectric-piezoelectric 116
- Ferroelectric PZT 139
- Ferroelectric RAM 139
- Ferroelectric Random Access Memory 149
- Ferromagnetic coupled memory 105
- Ferromagnetic layer 106
- Fert, Albert 240
- FeS 123
- FET *see* field effect transistor (FET)
- FeTiO<sub>3</sub> 123, 191
- Fe<sub>0.67</sub>W 103
- Feynman model 27
- Feynman, Richard 12
- Fiebig, M. 99–100, 104, 120
- Field effect transistor (FET) 183, 191, 196–99, 211–12
- Films, oriented YIG 236
- First electromagnetic coil 64
- First heat treatment 39
- First Landau's theory of second-order phase transition 130
- First magnetoelectric 103
- first order phase transition (FOPT) 128–29
- Flux growth method 50
- Food Processing 209
- FOPT *see* first order phase transition (FOPT)
- Forbidden band 27–29, 155
- Forbidden band II 28
- Force microscopy 68
- Fortunato, E. 181, 213  
forward biased 177
- Foundations of Applied Superconductivity 31
- Fourfold 88
- Fourier transform 81
- Four-Point Probe 163
- FRAM 138
- France 11, 29, 60, 123, 237, 240, 249
- Frederick, J. 151
- French mineralogist 88
- French physicist 28, 73, 102–3, 141, 222, 234
- French physicist Brillouin 253
- French physicist brothers 108
- French Physicist Pierre Curie 148
- Frequency dependence of energy density of CCTO 220
- Frequency dependence of IHC 194–95, 198–99
- Frequency dependence of optical absorption coefficient 167
- Frequency dependence of permeability and loss tangent 233
- Frequency dependence of power 222
- Frequency spectrum of permittivity 6
- Frequently used symbols and units 259, 263
- Fridkin, V. 151
- Friedrich Carl Alvin Pockels 249
- FTJ (ferroelectric tunnel junction) 122, 139
- Fukumura, T. 213
- Fundamental nature of electrical conductivity 1, 4
- Fundamental optical properties 248
- Fundamental physical constants and frequently used symbols and units 259
- Fused quartz 154, 248
- Fused quartz SiO<sub>2</sub> 254
- FWHM 61–62

## g

- GaAs *see* Gallium arsenide (GaAs)  
 Gadolinium molybdate  $Gd_2(MoO)_3$  140  
 Ga Ge 216  
 Ga Indium 17  
 Galileo Galilei 58  
 Gallagher, R.C. 213  
 Gallium 17, 158  
 Gallium arsenide (GaAs) 2–3, 30, 47, 62, 66, 82, 84, 154, 156, 160, 167, 176–77, 181–82, 251, 254  
 GaN 84, 154, 181–82  
 GaN III 168  
 $Ga_2O_3$  173  
 GaP 84, 182  
 Gauss 19, 203, 211, 232, 243  
 Gaussian 231–32  
 Gaussian units 231  
 Gauss magnetic fields 243  
 Gaussmeter 205  
 GB (grain boundary) 40, 126, 186–88, 196, 204, 207, 211, 213  
 GBG junction 190  
 Gd 18, 230, 235  
 Gd-Ga-garnet 49, 52  
 Gd-Sc-Al garnet 52  
 Gd-Sc-Ga garnet 52  
 Ge 2–4, 7, 30, 51, 54, 84, 92, 154, 156, 158, 161, 166, 171, 177  
 Ge IV 168  
 Ge Tin 17  
 Geiger, P.H. 213  
 Gem quality crystals 54  
 General Capacitor 218  
   general 34  
 Generated lattice type 89  
   generating 59  
 Generation of Sound 114  
 Geothermal electricity 216  
 Gerber 68  
 Gerd Binnig 64  
 Gerlach, Walther 14  
 German crystallographer 88  
 Germanium (Ge) 231  
 German physicists 14, 81, 249  
 German Proverb 33  
 German speaking countries 208  
 German word 78, 238  
 Germany 2, 7–8, 12–13, 19–20, 27, 59–61, 63, 65, 69, 96, 120, 164, 176, 238, 240  
 Germer, Lester 12  
 Gerog Ohm 2  
 GHz 6, 115  
 Giaever, Ivar 18, 22  
 Giaever junction 23  
 Giaever tunneling 22  
 Giant magnetoresistive 203  
 Giant PV 222  
 Gibbs, J. Willard 34, 130–32, 134, 148–49  
 Gibbs energy 149  
 Gibbs function 131, 148  
 Gibbs phase rule 34–35, 37, 55  
 Ginsberg 121, 130  
 Ginsburg 130  
 Ginsburg's work 130  
 Ginzburg, V. 18  
 Gittertheorie 120  
 Glossary 29, 54, 70, 91, 118, 148, 170, 210, 227, 242, 254  
 $G_m$  193–94, 197–98  
 GMO Electro-optics 140  
 GMR 239, 243  
 GMR and CMR effects 239, 241  
 GMR and CMR materials 240  
 GMR effect 240–41, 243  
 GMR superlattice device 241  
 Goddard, D.W. 55  
 Goeking, K.W. 53, 55  
 Gong, G. 245  
 GPS 115  
 GPS system 229  
 Grain boundary *see* GB (grain boundary)  
 Grain resistance RG 186  
 Great Britain 22  
 Greek origin 58  
 Greek philosopher 143  
 Greek philosophers Thales 203  
 Greeks 54, 58, 118, 143, 203  
   Geiger, Greg xiv  
   Greek word 43, 143  
   Greek word piezo 108  
 Grondahl, L.O. 213  
 Group II 78, 108–9, 156, 190, 235  
 Group II members 78  
 Group II point groups 108  
 Group III 16–17, 78, 156–57, 190  
 Group III members 78  
 Group IV 17, 74, 83–84, 156–57, 190  
 Group IV atoms 157  
 Group IV elements 157  
 Group IV semiconductors 157  
 Group VI elements 17  
 Group VIII 16  
   grown ferroelectric 145  
 Grünberg, P. 240  
 GSAG 52  
 GSGG 52  
 Günther, K.G. 46, 55  
 Gütthner, P. 69, 71

## h

- Hall, Edwin 168  
 Hall conductance 169  
 Hall conductivity 170  
 Hall constant 169  
 Hall effect 168–69, 200, 205  
 Hall effect experiment 169, 171  
 Hall effect Gaussmeter 203  
 Hall effect measurements 169  
 Hall effect method 166, 168  
 Hall effect sensor 203  
 Hall effect set 200  
 Hall element 213  
 Hall force 168–69  
 Hall probes 169  
 Hall voltage 169, 200  
 Hamilton, Sir William 12  
 Hamiltonian, H. 13  
 Hamiltonian, corresponding 12  
 Hamiltonian mechanics 12  
 Hamiltonian operator 12–13  
 Han, Hui xiv  
 Handbook 42, 55  
   Harold, Stern xiv  
 H-atom 236  
 Hawking, Stephen 153  
 HAXRD (high-angle X-ray diffraction) 61  
 Haynes 166–68  
 Heatable sample stage 45  
 Heated cathode 64  
 Heated Knudsen sources 46  
 Heating effects in Thermistors 207  
 Heat Vibration 216  
 Heckmann, G. 96, 120  
 Heckmann diagram 95–96, 99  
 Heckmann diagram in figure 96  
 Heisenberg model 235  
 Heisenberg's Uncertainty Principle 7, 11, 13  
 Heisenberg, Werner 13  
 Helium 16  
 Hell, Stefan W. 59  
 Henry H 263  
 Herbert, J.M. 147, 151, 214  
 Hermann, Carl 88  
 Hertz, Heinrich 8, 263

- Hexagonal and Cubic Close-packed Structures 73, 85
- Hexagonal and trigonal structures 81
- Hexagonal Uniaxial 250
- H-FET 196, 198, 212
- H-FET and E-FET transistors 198
- H-FET device 199
- H-FET transistor 199, 201–2
- H-field 211
- Hg 17, 59
- HgBa<sub>2</sub>Ca<sub>2</sub>Cu<sub>3</sub>O<sub>8</sub> 18
- High-angle X-ray diffraction (HAXRD) 61
- high-angle 61
- High densification and compaction 41
- High density MRAM 241
- High-intensity ultrasound 115
- High-resolution XPS spectrum of Bi<sub>4</sub>f of Bismuth ferrite film 67
- High temperature and high pressure growth 53
- High Temperature Solution Growth *see* HTSG (High Temperature Solution Growth)
- High temperature superconductor oxides and colossal magnetoresistive materials 149
- High voltage source 64
- H-ions 75
- HIP (Hot Isostatic Pressing) method 41
- HIP and CIP methods 41
- Historical perspective 121, 123, 143
- Ho 235
- Hoffmann, B. 204, 214
- Holograms 254
- Hooke's law 68, 97, 110
- Hooten 137–38, 151
- Hot Isostatic Pressing *see* HIP (Hot Isostatic Pressing) method
- HTSG (High Temperature Solution Growth) 50–51, 54
- HTSG growth 54
- HTSG method 51–52
- Hua, Z. 214
- Human ears 255
- Hund, Friedrich 238
- Hund's rule 238–39, 244
- Hur, N. 120
- HUS (high utilization sputtering) 49
- HV-Sputter-24 48
- Hybrid storage 218
- Hypothetical models 87
- Hypothetical models of centrosymmetric 87
- Hypothetical models of centrosymmetric and noncentrosymmetric crystals 73
- i**
- Iagrate, G.J. 55
- IAS (ion-assisted sputtering) 49
- IBM 241–42
- IBM laboratories 64
- IBM Zurich Laboratories 18
- IBS (ion beam sputtering) 49
- Idealized energy band diagram 156
- Idealized hysteresis loops 101
- IHC 180, 190–202
- Important binary semiconductor materials 84
- Important concepts 1, 18, 36, 148, 161, 175, 211
- Important concepts of semiconductor materials 153, 158
- InAlAs 241
- InAs 46
- India 143, 222, 253
- Indigo 180
- Indium 158
- Indium antimonide 154, 167
- Indium tin oxide *see* ITO (Indium tin oxide)
- Infinite electrical conductivity 19
- Infrared detection 146
- InGaAs semiconductor 241
- Ingram School xiv, 40
- In<sub>2</sub>O<sub>3</sub> 173, 179–80
- InP 3, 84
- Insanity 57
- InSb III 168
- InSb 3, 46, 154, 167
- inspired 10
- insulating SiO<sub>2</sub> 139
- Integrated films 112, 114
- Integration of multi-functional oxide 71
- Intensity of sound 114
- Interdiffused titanium layer 252
- intergranular capacitor 186
- intergranular resistance 186
- International Table for Crystallographers 88
- Intrinsic region 165
- Introduction 1, 33, 57, 73, 95, 121, 153, 173, 215, 228–29, 247
- Ions, central Ti<sup>4+</sup> 140
- Ireland 12
- IrO<sub>2</sub> 139
- iron-titanate 190
- IR-UV 6
- Ising model 235
- Italy 24
- ITO (Indium tin oxide) 173, 181, 183
- ITO contacts 183
- j**
- James Prescott Joule 208
- James Roy Newman 121
- Jan 51, 54
- Japan 181
- Jian Zhong xiv
- Jie-Fang Li, D. 151
- Jin, S. 245
- John 1, 18–19, 29, 33, 84–85, 93, 95, 147, 150, 153, 173, 181, 190, 247, 257, 259, 261, 263
- Attia, John 213
- Kerr, John 250
- Jona, F. 151
- Valasek, Joseph 123
- Josephson, Brain David 22–23
- Josephson effect 19, 22, 29
- Josephson junction 19, 22–24, 30
- Josephson junction device 242
- Josephson junction effect 19
- Josephson junction in high-speed data transfer 22
- Josephson junctions in series 22
- Josephson tunneling effect 18
- Josiah, Willard Gibbs 34, 149
- Joule, James 106
- Joule heating 20, 208–9
- Jullère, M. 245
- Jullière's formula 241
- k**
- Kahing, D. 213
- Kao, K.C. 111, 120, 140, 150, 221, 228
- Kasap, S. O. 31, 245, 255
- Katiyar, R.S. 120
- KCl 82
- KDP 131, 252
- KDP infrared detector 140
- Keithley 145–46
- Kelvin K 235, 263
- Kerr, John 250
- Kerr coefficient 250
- Kerr effect 247, 249–50, 254
- Kerr microscope 250

- $\text{KH}_2\text{PO}_4$  131  
 Kinetic energy of emitted electron 8  
 Kirchhoff 192  
 Kishan, Alysha xiv  
 Kittel, C. 84–85, 93, 140, 151  
 KLN electro-optics 140  
 KN 129, 131  
 $\text{KNaC}_4\text{H}_4\text{O}_6$  123, 131  
 $\text{KNbO}_3$  36, 49, 53, 131, 140, 251  
 KN electro-optics 140  
 Knipping, Paul 61  
 Knudsen effusion cells and electron beam evaporators 47  
 Kotru, S. 120, 151  
 Kr 16–17, 75  
 KrF excimer laser 44  
 Kronig, Ralph 27–28, 30, 155  
 K-space 81  
 $\text{KTaO}_3$  49, 53, 140  
 KT Electro-optics 140  
 KTN 49, 52–53, 129  
 KTN crystals 53  
 KTN electro-optics 140  
 KTN substrate 49  
 Kumar, A. 120
- I**
- $\text{La}_{1-x}\text{Sr}_x$  242  
 $\text{La}_2\text{O}_3$  186, 209  
 $\text{La}^{3+}$  207  
 $\text{LaAlO}_3$  substrate 241  
 $\text{LaAlO}_3$  104  
 $\text{LaCa}_{0.77}\text{Mn}_{0.33}\text{O}_x$  241  
 LAD (laser ablation deposition) 45, 55  
 LAM (laser ablation method) 43, 241  
 $\text{LaMnO}_3$  104, 225, 242  
 Landau 121, 130  
 Lapis Electricus 143  
 Laplacian operator 12  
 Large solar panels 222  
 Laser-assisted film growth of electronic materials 44  
 La-Sr-Cu-oxides 129  
 Latin 123  
 Laue, Max von 61–62  
 Laue diffraction 61, 71  
 Laue diffraction pattern 62, 71  
 Laue method 63  
 Laue patterns 62  
 Laue's guidance 61  
 Laue's hunch 61  
 Laue X-ray diffraction method 61
- Layers 42, 44, 45, 47, 49, 86, 106, 139, 186, 199, 210, 215, 240, 241  
 LCR meters 137  
 Lead-acid 218  
 LEDs (light-emitting diodes) 160, 179, 181  
 LEDs, blue 181  
 Leggett, Anthony J. 18  
 Lenz, Heinrich 208  
 Lenz law 168, 208, 239  
 Leonid 15  
 Levinson, L.L. 187, 213  
 Lewis, Gilbert N. 8  
 LFST (low-frequency sinusoidal temperature) 145  
 LFST technique 145–46  
 LGD 130, 140  
 LGD theory 132, 134, 140  
 Li 16, 245  
 Li-conducting  
   Li-alumintirano-phosphate 209  
 LiF Zone 54  
 Light-emitting diodes *see* LEDs (light-emitting diodes)  
 Light waves propagate in space 252  
 Li Mg Mn 216  
 Limited Solubility in Solid Phase 37  
 Lin 214  
 Li-Na-ion BSH 220  
 $\text{LiNbO}_3$  (Lithium niobate) 52, 116, 140, 221–22, 247, 251  
 $\text{LiNbO}_3$ -based waveguide 251  
 $\text{LiNbO}_3$  crystal 255  
 $\text{LiNbO}_3$  crystal substrate 252  
 $\text{LiNbO}_3$  substrate 252  
 $\text{LiNbO}_3$  surface 251  
 $\text{LiNbO}_3$  Trigonal 250  
 Linnaeus, Carl 143  
 LiO 42  
 Liquid Phase Epitaxy (LPE) 34, 43, 49, 54  
 Li Sodium 16  
 List of Nobel Prize in Physics 18  
 $\text{LiTaO}_3$  52, 116, 140, 147, 221  
 Lithium niobate ( $\text{LiNbO}_3$ ) 251, 254  
 Lithium tantalate 52, 111, 140, 147, 221  
 LMO 104  
 LN electro-optics 140  
 $\text{ln PO}_2$  210  
 $\text{ln VlnI}$  202  
 Local poling of ferroelectric polymers by scanning force microscopy 71
- Lock-in-amplifier 112  
 Lode-stone 203  
 London penetration depth 20–21  
 Long term reliability 181  
 Lord Rayleigh 115  
 Los Alamos National 191  
 Los Alamos National Labs 237  
 Louis de Broglie 11, 29  
 Lowest symmetry 90  
 Low temperature multiferroics 103  
 Low-voltage STEMs 65  
 LPE *see* Liquid Phase Epitaxy (LPE)  
 LPE growth technique 49  
 LPE method 43, 49, 54  
 LPE method for film growth 49  
 LPE technique 54  
 LSM 225  
 LSMO 104, 242  
 LSMO electrodes 242  
 LT electro-optics and pyroelectric devices 140  
 LTP 42  
 LT  $\text{PbTiO}_3$  131  
 LTS (low temperature sintering) 41–42  
 Lu 245  
 $\text{LuMnO}_3$  103  
 Lyman series 10  
 Lynn, E.G. 145, 151  
 Lyshevski, S.E. 55
- m**
- Mach 252  
 Madame Curie of France 60  
 Madame Marie Curie 234  
 MAGFET 199, 212–13  
 Magnesium 16  
 Magnetic and electric parameters 232  
 Magnetic Curie point 191  
 magnetic Fe-atom 237  
 Magnetic field diagram 95, 99–100  
 Magnetic field effect transistor H-FET 191  
 Magnetic force microscope *see* MFM (Magnetic Force Microscope)  
 Magnetic GGG 49  
 Magnetic nature 16  
 Magnetic nature of electron 229, 235  
 Magnetic nature of superconductivity 20  
 Magnetic sensors, based VDR 204–5  
 Magnetization 234

- Magnetolectric effect in composites of piezoelectric and piezomagnetic phases 120  
 magneto-optic 250  
 magneto-optic Faraday 236  
 Magnetoresistance 205  
 Magneto-resistance *see* MR (magneto-resistance)  
 Magneto-resistive coefficient *see* MRC (magneto-resistive coefficient)  
 Magnetotransistor 203  
 Magnetron 48, 54  
 Magnifying power and resolution 59  
 Manufacturing cost 181  
 Marcos, San xiii–xiv, 40, 48, 66, 71  
 Martins, R. 213  
 Mass of neutron 259  
 Mass of proton 259  
 Mater 71, 120, 213  
 Mathematical representation 109  
 Mathematical representation of piezoelectric effects 109  
 Matrices 93, 120  
 Matthessen's rule 5  
 Mauguin method 88  
 Max R 203  
 Maximum MR peaks 205  
 maximum power 224  
 Max Planck Institute 19  
 Maxwell, James Clark 8, 24, 155  
 Maxwell relation 98  
 MBE (Molecular Beam Epitaxy) 34, 43, 46–47, 54, 104  
 MBE, poor man 47  
 MBE film growth technology 47  
 MBE laboratory 48  
 MBE method 46, 62  
 MBE systems 47  
 MBE technique 46–47, 54  
 MBE technology 47  
 MBE unit in operation for oxide growth 48  
 McCormac, M. 245  
 Mecklenborg, Mark xiv  
 Meissner, Walther 20–22  
 Meissner effect 20  
 Memory, tunable capacitors Fe-RAM non-volatile 122  
 MEMS 112, 118, 123, 222  
 MEMS actuator 116, 119, 222  
 MEMS applications 113  
 MEMS cantilever 117  
 MEMS devices 118  
 MEMS power generator 222  
 MEMS sensors 241  
 MEMS structures 118  
 MEMS technology 118  
 Mendeleev, Dmitri 15  
 MENU 1, 33, 57, 73, 95, 121, 153, 173, 215, 229, 247  
 MeRAM 105, 241  
 MERAM memory 105  
 MERAM technology 106  
 Mermin, N.D. 31  
 Merz, W.J. 125, 128, 137–38, 150–51  
 Metallic Bonding 74  
 Metallic Pb 50  
 Metallized path 115  
 Metal semiconductor contact 175  
 Meter 263  
 Methods for materials characterization 57, 59, 61, 63, 65, 67, 69, 71  
 Methods for powder compaction and densification 41  
 Methods for surface and structural characterization 57  
 Methods of ceramic processing 33, 38, 230  
 Methods of crystal growth 49, 53  
 MFM (Magnetic Force Microscope) 57, 68–70  
 MFM-generated image 70  
 MFM image 69  
 MFM magnetic force 71  
 MFM microscope 69  
 Mg 41, 81, 86  
 MgAl<sub>2</sub>O<sub>4</sub> 41  
 Mg calcium 16  
 MgCr<sub>2</sub>O<sub>4</sub> 207  
 MgO 82  
 Mg<sub>0.5</sub>W<sub>0.33</sub> 103  
 Mhaisalker, S.G. 213  
 MHz 49, 55, 194, 198, 232, 239  
 Mica 4  
 Micromachined part 222  
 Microwave Engineering 150, 255  
 Miletus 203  
 Miller, William H. 80  
 Miller indices 73, 80–81, 92  
 Miller indices for planes and directions 79  
 Miller rule for indexing crystal directions 80  
 Miller's rules of indexing 80, 81  
 Miscible Systems 35  
 Mixed perovskite 103  
 Mixture A<sub>0.5</sub>B<sub>0.5</sub> 36  
 MKS system 231  
 Mn Iron 17  
 Mn Mo 216  
 Mn<sub>2</sub>O<sub>3</sub> 191  
 Mn-doped PsB 193  
 Mn-doped pseudobrookite 191  
 MnFe 230  
 Mn-ferrite 234  
 MnO 102, 179, 234, 237  
 MnO<sub>2</sub> 186  
 MnO<sub>3</sub> 242  
 Mn-PsB 190–91, 193–94  
 MnPsB device 193  
 MnPsB voltage 194  
 MnTe 102  
 Modified electric field 96  
 Modified Hermann's nomenclature scheme 88  
 modified 119  
 modulated 24  
 MOG (metal oxide grains) 186  
 Mohan, G.R. 213  
 Molecular beam epitaxy *see* MBE (molecular beam epitaxy)  
 Molybdate PbMoO<sub>4</sub> 254  
 Momentum 13  
 Monoclinic biaxial 250  
 Morener, William E. 59  
 MOSFET (metal-oxide-semiconductor field effect transistor) 183, 196, 211  
 MOSFET structure 139, 196  
 MOSFET transistors 196, 242  
 Mostovoy, M. 120  
 Moulson, J. 147, 151, 214  
 MR (magneto-resistance) 205–6, 240–42, 244  
 MRAM (magnetic random access memory) 105  
 MR-based sensor 205  
 MRC (magneto-resistive coefficient) 201–2  
 MRC parameter 201  
 MRI (magnetic resonance imaging) 19  
 MR sensor 205  
 MR value 241  
 MTI Company 40  
 MTJ (multiferroic tunnel junctions) 105–6, 241  
 MTJ device 106  
 Müller, Alex K 18  
 Multi-ferroic magnetoelectrics 120  
 Multiferroics Phenomena 95, 99, 101

- Multiferroic tunnel junctions *see* MTJ (multiferroic tunnel junctions)
- Multifunctional magnetoelectric materials for device applications 120
- Multifunctional nature of ferroelectrics 122
- Multi-functional oxide 71
- Mulyukov, R.R. 55
- Munich 65
- Munsee, C.L. 213
- MW 123, 224–25
- MW-IR Frequency 6
- n**
- Na<sup>+</sup> -ions 82
- NaCl 7, 38, 71, 74, 82, 86–87, 224
- NaCl crystallizes in fcc structure 82
- NaCl crystals alkali metals and halides 74
- NaCl figure 84
- NaCl molecule 74
- Nagendra Nath 253
- NaI 54
- Na-ions 82
- NaK<sub>4</sub>H<sub>4</sub>O<sub>6</sub> 140
- Nan, C.W. 120
- NAND (Not-And) 105
- Nanoscale technology 151
- Nanoscience 42, 55
- NASA 224
- National high magnetic field laboratory 237
- National Institute 15
- Natural light 247
- Nature of Electrical Conduction in 153–55
- Nazarov, A. A. 55
- Nazi Regime 14
- Nb 19, 139, 146, 216
- Nb<sup>5+</sup> 207
- Nb-doped PZT 145, 147
- Nb doping 151
- Nb doping level 146
- Nb<sub>2</sub>O<sub>5</sub> 186
- Nb<sub>10</sub>O<sub>30</sub> BNN Electro-optics 140
- Nb<sub>10</sub>O<sub>30</sub> BSN Electro-optics Barium 140
- NCS 131
- Nd-doped yttrium aluminum garnet 252
- Néel, Louis 237
- Néel point 102–3, 230, 242–43
- Néel temperature 141, 230, 238, 243
- Néel theory 238
- Néel theory of antiferromagnetism 238
- Negative temperature coefficient *see* NTC (negative temperature coefficient)
- Neon 16
- Netherlands 18, 103, 163
- New Delhi 171
- New Mexico 237
- Newnham, R.E. 93, 107, 120
- Newton, Sir Isaac 12, 73
- Newton's laws 12, 208
- Newtonian acceleration 160
- Newton's mechanics 12
- New York 93, 120
- New Zealand 10
- n-GaAs 181
- NH<sub>2</sub>CH<sub>2</sub>COOH 131, 140
- NiCd 218
- NiCd batteries 218
- Nichrome 5
- Niels Henrik David Bohr 10
- Niels 236
- NiFe<sub>2</sub>O<sub>3</sub> 230
- NiFe<sub>2</sub>O<sub>4</sub> Nickel 242
- NiFe<sub>2</sub>O<sub>4</sub> 53, 235
- Ni-ferrite 234–35
- Night vision devices *see* NVD (night vision devices)
- NiO 179, 207, 230, 234, 237
- Niobate Ba<sub>5x</sub>Na<sub>5</sub> 140
- NIST 15, 22
- NLC 185–86, 190, 192, 200, 202, 204–6, 212
- NO<sub>2</sub> 209
- Nobel Committee 8
- Nobel laureates 18
- Nobel Lecture 95
- Nobel Prize 18–19, 64
- Nobel Prize, second 19
- Nobel Prize in chemistry 10, 59
- Nobel Prize in physics 7–8, 10, 12–14, 18, 22, 24, 29, 60, 63, 181, 188, 190, 237, 240, 253
- Noise 62
- non-MEMS 220
- Nonohmic contact 163, 178
- Nonoxides 103
- Non-polar 109
- Normal electron 23, 29
- Normalized MR 206
- Norwegian-American physicist 22
- Not-And (NAND) 105
- Novel Magnetic Technologies 229, 239
- NSEC response time detector 151
- NSMs 42
- NTC (negative temperature coefficient) 207, 209, 211
- NTC sensor 174
- NTC thermistors 209
- NVD (night vision devices) 9, 252–53
- Nye, J. E. 93, 120
- o**
- O<sub>3</sub> 141
- observed MR 241
- Ocean power 216
- Ochsenfeld, Robert 20
- Ochsenfeld effect 20–22
- Oe 204–6, 211, 232, 236
- Oersted 211, 232
- Ohm's law 2, 22, 183, 189, 208
- O-ions 75
- open-circuit voltage 224
- operating 47
- Onnes, Heike Kamerlingh 18
- Optical classification 250
- Optical classification of crystals 250
- Optical fibers and rectangular dielectric slab waveguides 251
- Optical Waveguides 251–52
- optical 252
- Ordered configurations of ferromagnetic 238
- Ordinary ball milling 39
- Ordinary ray 249
- Organic solids 75
- Oriented Nb-doped Pb 151
- oriented 236
- Origin of Holes 153, 156
- Origin of potential barrier 174
- Origin of Voids and Atomic Packing Factor 73, 84
- original 136, 218
- Orlando, T. P. 18, 31
- Ortega, N. 103, 105, 120
- Orthorhombic Tetragonal 129
- Output current 191, 198
- Output transduction 221
- Oxford Science Publications 171, 214
- Oxford University Press 31, 91, 93, 120, 171, 214, 245, 261, 263
- Oxford University Press Source 255
- Oxide Co<sub>3</sub>O<sub>4</sub> 231
- Oxide CuO 231

- Oxide FeO 231  
 Oxide GeO 231  
 Oxide NiO 231  
 Oxide semiconductor materials 179  
 Oxides of perovskite structure 242  
 Oxide spintronics 245  
 Oxide TFT 183  
   oxide-based 180  
   oxide-based TFT 180  
 Oxygen, tetragonal TB 130  
 Oxygen B-atoms 235  
 Ozone 47
- P**
- Padmini, P. 171, 213  
 Palladium (Pd) 9, 35  
 Pandey, Christa xiv  
 Pandey, R.K. 1–257, 259, 261, 263  
 Paraelectric phase 134  
   parallel impedance 187  
 Parallelogram 89  
 Paramagnetic 16, 230–31, 238  
 Paramagnetic copper 231  
 Paramagnetism Paramagnetic materials 243  
 Parameters  $B_{rem}$  232  
 parent IHC 45varistor 198  
 Paris 148  
 Park 120, 213  
 Parkinson's disease 115  
 Pascal 35  
 Paschen series 10  
 Patent 151  
 Pauli, Wolfgang 14  
 Pauli's Exclusion Principle 1, 14–15, 19, 24, 27, 29–30, 238, 244  
 Pauli's selection rules 235  
 Pauw, van der, L.J. 163  
 Pauw method 163  
 Pb 17, 38, 86, 103, 131, 141, 216  
 Pb-based materials 103  
 Pb-based solid solution 141  
 PbF<sub>2</sub> 50  
 Pb-ions 103  
 Pb<sub>2</sub>KNb<sub>5</sub>O<sub>15</sub> 130  
 Pb<sub>3</sub>Mg<sub>3</sub>Nb<sub>2</sub>O<sub>9</sub> 127  
 PbNb<sub>2</sub>O<sub>6</sub> 130  
 PbO 50, 204  
 PbO<sub>2</sub> 50  
 PbO and boron oxide 50  
 Pb Pt St 216  
 PbS 82  
 PbSe 54, 167  
 PbTa<sub>2</sub>O<sub>6</sub> 130  
 PbTe 54, 154, 166  
 PbTiO<sub>3</sub> 36, 51, 140–41, 221  
 PbZrO<sub>3</sub> 102, 140–42, 221  
 PbZrO<sub>3</sub> crystal 140  
 PbZrO<sub>3</sub> Perovskite 141  
 Pb-Zr-titanate 139  
 PbZr<sub>1-x</sub>Ti<sub>x</sub>O<sub>3</sub> 104, 140–41  
 peak MR 205–6  
 PE effect 222  
 PEMFC (proton exchange membrane fuel cell) 224–25, 227  
 PEMFC devices 224–25  
 PEMFC technology 224  
 PEM fuel cell 224  
 Penn State University 42  
 Penney, William 27, 30  
 Penney model 27–28, 155  
 Permanent Dipole Bonding 75  
 Perovskite Bi<sub>1-x</sub>Nd<sub>x</sub>FeO<sub>3</sub> 227  
 Perovskite calcium titanate (CaTiO<sub>3</sub>) 55, 82  
 Perovskite CuTiO<sub>3</sub> 55  
 Perovskite Orthorhombic 18  
 Perovskite TbMnO<sub>3</sub> 103  
 Perovskite Tetragonal 18  
 Perovskite Variable 141  
 Pertinent properties of IHC 198  
 PFM (piezoelectric force microscope) 57, 68–71, 108, 126, 137–38  
 PFM micrograph 70  
 PFM microscope 71  
 PFM probes 69  
 PFN 103  
 PFN-Pb 103  
 PFT 103  
 PFW 103  
 PFW-Pb 103  
 Phase diagram of bismuth sodium titanate and barium titanate 141  
 Phase shifters 252  
 Philips Labs 163  
 Phillip, H.R. 187, 213  
   phosphate 140  
 Phosphorous 158  
 Photon energy, single UV 46  
 Physical properties of crystals 93, 120  
 Physicists, celebrated English 115  
 Physics, recipients of Nobel Prize in 29, 60  
 Physics Nobel Prize 60–61  
 Pierce, John R. 190  
   Pierre 60, 108, 234, 236  
 Pierre-Ernest Weiss 234  
 Piezo effects 118  
 Piezoelectric and allied phenomena 150  
 Piezoelectric charge and stress coefficients 113  
 Piezoelectric force microscope *see* PFM (piezoelectric force microscope)  
 Piezoelectric frequency oscillator 116  
 Piezoelectric PZN 51  
 Pi for ionic polarization 6  
 Pittman, G.E. 160, 171, 181, 213  
 PKN 130  
 Planck, Max 7–8, 10–11, 30  
 Planck constant/ Planck's constant 7–9, 11, 22, 26, 46, 159, 164, 212, 259  
 Planck constant, reduced 236  
 Planck's law of radiation 11, 46, 59, 159  
 Planck's photon energy 30  
 Planck's radiation law 7, 10  
 Planck's theory 11  
 Planes/unit cell Crystal structure  
   Crystal unit cell 18  
 PLD (pulsed laser deposition) 43–46, 55, 104  
 PLD, daily maintenance 47  
 PLD chamber 45  
 PLD experiment 46  
 PLD growth 44  
 PLD growth chamber 45  
 PLD method 44–45, 104  
 PLD system 45  
 PLD technique 45  
 PLD unit 46  
 Plot for time-dependent voltage output for Haynes 168  
 PLZT 41, 108, 127, 253  
 PMN 108, 126–27, 149  
 PMN-PT 108, 127  
 PNZT 131, 145  
 PNZT film 145–46  
 Pockels cells 249  
 Pockels effect 247, 249–52, 254  
 Pockels effect and Kerr effect 247  
 Poisson equation 189  
 Poland 51, 54  
 Polarity/mobility 191  
 Polarization vectors in neighboring lattices 141  
 Polar-molecule-induced dipole bonds 75  
   poled 146

- Poling of samples for experiments  
134  
polished 166
- Pollution control Radiometry  
Pyroelectric 122
- Pollution monitoring 147  
polycrystalline 111, 186
- Poly-Si 139
- Polyvinyl chloride 4, 111
- Positive Sapphire  $\text{Al}_2\text{O}_3$  Trigonal  
250
- Positive temperature coefficient *see*  
PTC (positive temperature  
coefficient)
- Potassium 16
- Potassium chloride 82
- Potassium lithium niobate  
 $\text{K}_5\text{Li}_2\text{Nb}_{10}\text{O}_{15}$  140
- Potassium niobate  $\text{KNbO}_3$   
251
- Potassium-sodium  
tartrate-tetrahydrate 131
- Potassium tantalate niobate  
 $\text{KTa}_{1-x}\text{Nb}_x\text{O}_3$  140
- Potential barrier WB 176
- Potential barrier WC 178
- Potential WC 178
- Powder diffraction method 60  
powder of 55
- Prairie View A&M University xiv
- Predictive Nature 86
- Predictive Nature of Crystal Structure  
73, 86
- Prefixes commonly used 261
- Prentice Hall 171
- Presley, R.F. 183, 213
- Primitive Cubic Structure 85  
primitive 85
- Principal bonds 74
- Principal effect 96–97
- Principles and Applications of  
Ferroelectricity 151
- Principles and Applications of  
Ferroelectrics 93
- Processing of electroceramics 33–35,  
37, 39, 41, 43, 45, 47, 49, 51, 53,  
55  
producing high-quality 35
- Producing NSMs 47
- Production of birefringence 249
- Droopad, Ravi xiv
- Projector lens 64  
prominent 36
- Properties and applications of varistor  
71
- Properties and potential applications  
202
- PsB 180, 190–91, 203–5
- PsB varistor 203
- PsB VDR 203, 205
- Pt/Al 176
- PTC (Positive temperature coefficient)  
4, 207, 209, 211
- PTC and NTC thermistors 209
- PTC devices 207
- PTC effect in ferroelectric 207
- PTC sensors 174
- PTC thermistor 207
- Pt/Si 178–79
- Pt/Si contact 178–79
- P-type conduction 153, 156  
p-type Ge 171
- P-type nature 164
- P-type Si-substrate 139
- P-type ZnO 181, 183  
p-type 169–70, 178, 195, 196
- Pulsed laser deposition *see* PLD  
(pulsed laser deposition)
- Pump electron-gun 47
- Pure DC 135  
pure 185
- PV 217
- PVA 39
- PVD (physical vapor deposition) 47
- PV devices 223
- PVDF copolymer 108
- PV effect 222–23
- Pyrex glass vessels 53
- Pyroelectric coefficient  $\text{P}_i$  98
- Pyroelectric coefficients of selected  
materials 147
- Pyroelectric TGS 53
- Pyromagnetic effect 77
- Pyrometer 45
- Pyro-optic Effect 121, 147, 149
- PZT 89, 104, 111–14, 117–18, 125,  
129, 131, 138–42, 150, 221, 223,  
227
- PZT actuators 117
- PZT cantilever 112–13, 117
- PZT capacitors 141
- PZT ceramic 147
- PZT energy harvester 227
- PZT ferroelectric film 104
- PZT film cantilever 113
- PZT films 105, 112
- PZT materials 141
- PZT MEMS cantilever 117
- PZT Piezoelectric devices and  
memory 140
- q**
- Qualitative comparison 231
- Quantization of magnetic flux 22
- Quantum Hall effect 169
- Quantum Mechanics and Magnetism  
238
- Quartz  $\text{SiO}_2$  Trigonal 250
- r**
- Radiant Technologies 136
- Radiation Law 7
- Radio frequency *see* RF (radio  
frequency)
- Radio frequency ID cards 122
- Radio frequency magnetron sputtering  
method 43
- Radiometry 147
- Radon 16
- Ragone, D.V. 228
- Ragone chart 218
- Ragone Plot 218
- Rahman, Shafiqur 71
- RAM *see* random access memory  
(RAM)
- Ramamoorthy, Ramesh 103, 120
- Raman, C.V. 253
- Ramanujan, Srinivas 121
- Random access memory (RAM) 105,  
149, 241
- Rapid cooling 50
- Ratcliff, N.M. 214
- Ravi Droopad 48, 66
- Raw materials II 44
- Raw materials III 44
- RBS (Rutherford Back Scattering) 57,  
67
- RC circuit 135
- Recent Applications of Ferroelectric  
Materials 121, 138  
redox electrolytes 220
- Reduced Planck constant 259  
reduced 8
- Refractive index of selected materials  
248
- Region, near-IR 182
- Relationship MR 206
- Relative emitted radiation 182
- Reller, A. 228  
remnant point 232

- Representation by Tensors and Matrices 93, 120
- Representation of coupled properties in solids 77
- Residual gas measurement 47
- Residual resistivity 5
- Resistance temperature detectors *see* RTDs (resistance temperature detectors)
- resistive 106
- Resistivity of CCTO 180
- Resistivity of solids 4
- Review of Battery Systems for Electrically Powered Vehicles 228
- RF (radio frequency) 43, 114, 122–23, 150, 255
- RFeO<sub>3</sub> 235
- RF frequency 55
- RFID 122
- RFID tag 220
- RF magnetron sputtering 49, 183
- RF magnetron method 43
- RF magnetron sputtering 49
- RF magnetron sputtering method 47
- RF sputtering 55, 104
- RF transformers 239
- RHEED 47, 55
- RHEED device 45
- RHEED Gun 45
- RHEED screen 45
- Richardson, Owen William 188, 213
- Richardson constant 188, 212
- Richardson equation 188
- Richardson law 188
- Robert 18–19, 29
- Rochelle salt 123, 131, 140, 150
- Rodgers Library xiv
- ROHM Co 138–39, 151
- role 215
- Rohrer, Heinrich 64
- ROM (read only memory) 105
- Röntgen, Wilhelm C. 60
- Röntgen-ray 60
- Room temperature properties and potential applications 201
- Room temperature pyroelectric coefficient and figure-of-merit 146
- Room Temperature Uniaxial Pressing (RTUP) 38
- Rotatable manipulator 48
- Rotatable sample manipulator 45
- Rotatable target assembly 48
- Rotating target holder 46
- Rotating/Tilting target 45
- Roundy, C.B. 145, 151
- Roundy method 145
- Rowell, John 23
- RSFQ (rapid single flux quantum) 22
- RTA (rapid thermal annealing) 183
- RTD device 207
- RTD elements 206
- RTDs (resistance temperature detectors) 206–7, 211
- RTUP (room temperature uniaxial pressing) 38
- RTUP method 41
- Rubidium 16
- Ruska, Ernest 63, 65
- Russian chemist 15
- Rutherford, Lord 10, 34, 57
- Rutherford equation 66
- Rutherford's model 10
- Rydberg constant 10–11
- S**
- SAE Technical Paper 228
- Saturn-V Rocket 173
- SAWs match 115
- Sawyer 135–36, 150–51
- Sb 157–58
- SBN (Sr-Ba-niobate) 52, 130–31, 147, 150
- SbSI 42, 148
- SbSI Pyro-optic 140
- Scanning tunneling microscope *see* STM (scanning tunneling microscope)
- Scattered electrons Auger electrons 63
- Scattering, small angle X-ray 60
- Schad, R. 213
- Scherrer Method 60
- Schmid, H. 100, 120
- Schönflies method 88
- Schönflies School 88
- Schottky, Walter H. 176, 196, 211
- Schottky barrier 176, 179, 186, 188, 192, 212
- Schottky barriers, double 188, 207
- Schottky barrier height 175, 177–78, 211
- Schottky diode 173–74, 176–78, 188, 196, 211–13
- Schottky diode in electroceramics 176
- Schottky diodes in back-to-back configuration 184
- Schottky effect 188
- Schottky gate 241
- Schottky height 192
- Schottky of Germany 176
- Schottky thermionic emission (STE) 188
- Schottky Transistor 195–96
- Schrieffer, Robert 23
- Schrödinger, Erwin 12, 24
- Schrödinger equation 7, 11–13, 24, 28
- Schrödinger's wave 28
- Schrödinger's wave equation 12
- Schrödinger's wave function 12
- Schwing, U 204, 214
- Scotland 250
- Scotti, J.F 120
- Sears 253
- Secondary electron 65
- Second electromagnetic coil 64
- Second harmonic generator (SHG) 252
- Second order phase transition 128–29
- Second soaking cycle range 50
- second 29
- Seebeck, Thomas Johann 164
- Seebeck coefficient 165–66, 171, 191, 206
- Seebeck coefficient for semiconductors 165
- Seebeck coefficient of Ge 171
- Seebeck Effect 164, 166, 171, 206
- Seed holder 52
- Selected antiferroelectric materials 141
- Selected Crystal Systems 73, 81
- Selected elector-optical crystals 251
- Selected electro-optic applications 251
- Selected ferroelectric materials 140
- Selected metals and oxides 166
- Selected piezoelectric materials 111
- Selected single-phase multiferroic materials 103
- Semiconductor BJT transistors 199
- Semiconductor contacts 173–74
- Semiconductor materials groups IV 154
- Semiconductor MOS transistor 199
- Semiconductor properties 3, 153, 162

- Semiconductors 1–6, 16, 17, 24–27, 29, 42, 49, 53, 82–84, 121, 153–161, 164–166, 168, 169, 173–176, 179–181, 183, 206, 207, 209, 211
- Semiprecious crystal tourmaline 98
- Shamsuzzoha, M. 213
- Sharma, P.A. 120
- SHG (Second harmonic generator) 252
- Shimizu, Y. 214
- Shirane, G. 151
- Shockley, William 190
- Shockley experiment 167–68
- Shockley method 166–67, 171
- Short-circuit current density  $J_{sc}$  224
- Shuji Nakamura 181
- $Si_3N_4$  69
- $Si_4$  74
- SiC-based Schottky 177
- Siemen 212
- Signature properties of ferroelectric materials 121, 123
- Signature properties of superconductors 1, 19
- Simmons, J. 228
- Single crystal GaAs substrate 61
- Single Crystal Growth Methods 49
- single crystal of 203–4
- Single crystal PsB 203
- Single crystal quartz 116
- Single Fe-atom 237
- single 189
- Sinhalese 143
- Sinter 39
- Sintering of nanosized ceramic powder 42
- SiO 52
- SiO<sub>2</sub> 52–53, 74, 114, 116–17, 139, 154, 186, 211, 221–22, 248
- SiO<sub>2</sub> cantilever 117
- SiO<sub>2</sub> cantilever device 118
- Si-technology 139
- Sites, site A2 site B1 site B2 130
- Sivanand, P.S. 214
- Sn 17, 38, 84, 216
- Snell's law 248
- SnO<sub>2</sub> 42, 173, 179–80, 183–84, 186, 209–11
- SnO<sub>2</sub> alloy 173
- SnO<sub>2</sub> varistors 185–86, 210
- Sn-oxide 183
- Sn<sub>0.63</sub>Pb<sub>0.37</sub> 38
- Socrates 203
- SOFC (Solid Oxide Fuel Cells) 224–25, 227–28
- SOFC cathodes 225
- SOFC cells 224
- SOFC devices 224–25
- Soft ferrites 233
- Solar 227
- Solar CSP Geothermal 216
- Solar energy and wind energy 215
- Solar heating/cooling 216
- Solar PV 216
- Solid materials 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29
- Solid oxide fuel cells *see* SOFC (solid oxide fuel cells)
- Solid solution 36–37
- Solid solutions PFW-PbTiO<sub>3</sub> 103
- Solid state 171
- Solid state electron 213
- Solid state physics 31, 93
- Solid-sublimation-condensation process 47
- Solution 9, 12, 13, 21–22, 24, 26, 27, 28, 35–37, 40, 42, 44, 49–53, 58, 59, 60, 62
- Solving STE equations 189
- Solymar, L. 31, 171, 214, 245, 251, 254–55, 261, 263
- SONARs 108, 118
- Song, X. 151
- Song dynasty 229
- Sons 1, 33, 84–85, 93, 95, 147, 150, 153, 173, 181, 247, 257, 259, 261, 263
- SOPT 128
- Sorbonne 148
- Source Wavelength 59
- Sources of vibration 221
- South Asia 143
- Spaldin, N.A. 99–100, 120
- special 85
- Spectrometer 166
- Speed monitoring 115
- Spin Hall effect 169
- Spin-polarized injection 242
- Spintronic material Co-La<sub>1-x</sub>, promising 242
- Split drain MOS structure 199
- SPM (scanning probe microscopy) 57
- Springer 79, 93, 120, 198
- Springer License 204
- Springer Verlag 151
- Squatrito, P.J. 55
- SQUID 19, 24, 30, 203
- SQUID magnetometers 19, 22
- Sr 139, 235
- Sr Barium 16
- Sr<sub>1-x</sub>Ba<sub>x</sub>Nb<sub>2</sub>O<sub>6</sub> 147
- Sr<sub>2</sub> 139
- Sr<sub>2</sub>CrRO<sub>6</sub> 242
- Sr-Ba-niobate *see* SBN (Sr-Ba-niobate)
- Sr-Ce-Yb-oxide 209
- SrCO<sub>3</sub> 40–41
- SrCO<sub>3</sub>SrO 41
- SrCO<sub>3</sub>TiO 41
- SrCO<sub>3</sub> of SrO 41
- SrFe<sub>12</sub>O<sub>19</sub> 233
- Sr-ferrite 233
- Sr-ferrite Hard Small 239
- Sri Lanka 143
- Srinivasan, N. 159, 168, 171
- Srivastava, C.M. 159, 168, 171
- SrNbO<sub>3</sub> 130
- SrO 40–41
- SrRuO<sub>3</sub> 242
- SrTiO<sub>3</sub> 4, 30, 36, 40–41, 66, 242, 248
- SrTiO<sub>3</sub> melts 41
- SrTiO<sub>3</sub> powder 41
- SrTiO<sub>3</sub> unit cells 40
- Sr<sub>x</sub>TiO<sub>3</sub> 242
- Standard atmosphere 259
- standard MOSFET 241
- Standards 15
- Stapleton, W.A. 71, 171, 213, 228
- STE (Schottky thermionic emission) 188
- Steel autoclaves work 53
- STEM microscope 64–66
- STE process 188
- Sterling, C. xiv
- Stern, Otto 14
- STM (scanning tunneling microscope) 64, 68, 71, 108
- STN 139, 141
- STN memory cell 139
- STO 62, 66, 242
- Stockberger 34
- Stockberger method growth 54
- STO interface 66
- STO layer 66, 242
- Streetman, B.G. 171
- strong Colombian 10
- Strong thermal dependence of resistivity 4
- strong 76
- Structures associated 234
- subject xiii

- Substrate, n-Si 177  
 Supercapacitor CCTO 55, 225  
 Superconducting phase Cooper pairs 19  
 Superior Power 49  
 Superparamagnetism 230, 243  
 Sutanto, I. 71, 213  
 Switzerland 28, 64, 68  
 Symmetry elements for pyroelectric 90  
 Symmetry elements for piezoelectricity 109  
 Symmetry elements for piezoelectric materials 90  
 Symmetry elements of centrosymmetric group 90
- f**
- Ta<sup>5+</sup> BT 207  
 Takao 214  
 Tamil 143  
 Tamil Nadu 143  
 Ta<sub>2</sub>Nb<sub>2</sub> 139  
 Tate, J. 71, 213, 228  
 Taylor's series 250  
 TB (tungsten bronze) 127, 130–31, 150  
 TB family 130  
 TB ferroelectrics 130  
 TbMnO<sub>3</sub> 103  
 TbMn<sub>2</sub>O<sub>3</sub> 103  
 TB structures 130  
 Tc 18–23, 35, 102, 124–26, 128–29, 131–34, 141–42, 148, 191, 207–8, 234, 237–38, 242  
 TCBCO 18  
 Tc temperature 20  
 Td 227  
 Teale, Gordon 51  
 Teller, Edward 215  
 Tellurium 166  
 Temperature coefficient of resistivity 5  
 Temperature dependence of critical magnetic field 21  
 Temperature dependence of ferroelectric parameters 125  
 Temperature dependence of inverse 133  
 Temperature dependence of magnetic parameters 234  
 Temperature dependence of resistivity of metals 5
- Temperature gradient conditions BGO 54  
 TeO<sub>2</sub> 90  
 TER 106  
 Tera 261  
 Tesla 19, 211, 231–32, 243, 263  
 Tetragonal Cubic 208  
 Tetragonal Orthorhombic 131  
 Tetragonal Uniaxial 250  
 Texas 40  
 Texas A&M University xiii–xiv, 21, 41, 191  
 Texas Instruments 51, 160, 181, 213  
 Texas State University xiii–xiv, 40, 48, 66, 71  
 TFT (thin-film transistor) 179–81, 183–84  
 TFT properties 181  
 TFT technology 183  
 TGS 131, 147  
 TGS infrared detector 140  
 Thallium 17  
 Theoretical considerations for varistors 173, 186  
 Theory of antiferroelectric crystals 151  
 Theory of superconductivity and superfluids 18  
 Thermal currents 11 177  
 Thermal properties of metals and semiconductors 24  
 Thermoelastic effect 96  
 Thin film ceramics 42  
 Thin-film forms 103  
 Thin-film transistor *see* TFT (thin-film transistor)  
 Thoramali 143  
 Ti<sup>4+</sup> 127  
 Tiefel, T.H. 245  
 time-dependent 13  
 time-independent 13, 28  
 TiO<sub>2</sub> 4, 30, 40–41, 55, 154, 173, 179–80, 183, 186, 209, 248  
 TiO<sub>2</sub> crystal 255  
 TiO<sub>2</sub> sensors 209  
 TiO<sub>2</sub> Tetragonal 250  
 TiO<sub>2</sub> waveguide 255  
 TiO<sub>2+</sub> 40  
 TiO<sub>3</sub> 147  
 TiO<sub>3-x</sub>BaTiO<sub>3</sub> 141  
 Titania 17, 154  
 Tl<sub>2</sub>Ca<sub>2</sub>Ba<sub>2</sub>Cu<sub>3</sub>O<sub>10</sub> 18  
 TMR 241–42  
 TMR effect 241
- TMR tunneling effect 242  
 Top seeded solution growth (TSSG) 52  
 Tower 135, 151  
 Tower circuit 135–36, 150  
 Toyosaki, H. 213  
 Traditional biomass Bio-heat Ethanol 216  
 Transconductor 191  
 Transducers and acoustic amplifiers 221  
 Transformers for low power applications 240  
 transparent 183  
 transparent SnO<sub>2</sub> 183  
 Triple Point and Interfaces 34  
 Triple points of selected materials 35  
 Tryglycine sulfate 140  
 TSC (thermally stimulated currents) 145  
 TSSG (top seeded solution growth) 52  
 TSSG method 53  
 Tungsten 5  
 Tungsten bronze structures 121, 127, 130  
 Turmai 143  
 Tuscaloosa xiv, 46, 120  
 TV broadcasting 115  
 TV screen 64, 182  
 Two-dimensional atomic distribution 86  
 Typical examples of crystal structures 73, 82  
 Typical structures associated 229
- u**
- U-238 15  
 Übung macht den Meister 33  
 UHF-MW 6  
 UHV (ultra-high vacuum) 46  
 UHV conditions 46  
 UHV environment 47  
 UHV-PLD-1X 45  
 Ultra 218  
 Ultra-sound waves 253  
 Ultra-violet *see* UV (ultra-violet)  
 Unbiased potential V<sub>0</sub> 200  
 Undetermined Signal 194  
 Unit Cell Triclinic 90  
 United States 15  
 University xiii–xiv, 18, 40, 46, 120  
 Unpolarized ray 249  
 US Defence Logistics Agency 218

- US Department of Energy 237  
 US DoE 191  
 US military 220  
 US Patent 213  
 US Patent Number 171  
 US universities xiii  
 Uuo 15  
 UV (ultra-violet) 6, 9, 59–60, 179, 181–82, 212, 223, 227, 247  
 UV-blue 181  
 UV laser 46, 224  
 UV light 30, 64, 253  
 UV photon 46  
 UV radiation 46  
 UV range 180  
 UV source 59  
 UV wavelength 46
- V**  
 Vacuum 8  
 Vacuum level 174–75  
 Valasek, J. 138, 150  
 Valence band, n-Type semiconductor 175  
 Valent Fe-ions, mixed 243  
 value of 185, 200  
 Values for Fermi energy 162  
 Values of Curie temperature of selected magnetic materials 234  
 Vapor phase method 42, 54  
 Varistor diodes 173, 184–85, 188–89, 212  
 Varistor-embedded devices 173, 190  
 Varistor microstructure 186  
 Varistor's NLC 205  
 varistor's 186  
 VBT (voltage biased transistor) 190–91, 193–95, 197, 212  
 VBT, embedded 194  
 VBT device 193–96, 198  
 VBT transistor 193, 195, 197  
 VBT transistor device 196  
 VCCS 194, 212  
 VDR (voltage-dependent-resistor) 184, 203–6, 212–13  
 VDR characteristics, corresponding 203  
 VDR device 204–6, 212  
 VDR device changes 205  
 Veda, Sam 247  
 Velocity of light in material 248  
 Velocity of light in vacuum 248  
 Verneuil method 54  
 Viehland, A.S.B 151
- Visible light microscopes 59  
 Voids and Atomic Packing Factor 73, 84  
 Voltage, differential Hall 199  
 Voltage biased transistor *see* VBT (voltage biased transistor)  
 Voltage biased varistor 190  
 voltage-dependent-resistor *see* VDR (voltage-dependent-resistor)  
 VPE technique growth of epitaxial films 55
- W**  
 Waals bond 74  
 Waals Bonding 75  
 Waals interaction 68  
 Walsh, D. 31, 171, 214, 245, 251, 254–55, 261, 263  
 Walter, H. 176  
 Wang, C. 214  
 Weiss, Pierre 236–37, 244  
 Weiss law 20, 125–26, 132–34, 139, 142, 234, 244  
 Weiss-mean-field theory 234  
 Weiss model 235  
 Weiss theory 237  
 Westinghouse Electric Corporation 199  
 Whatmore, R.W. 146, 151  
 white 61–62  
 Wiley 151, 214, 255  
 Wiley Eastern Limited 171  
 Wilhelm Conrad Röntgen 60, 103  
 Wilkins, Rick xiv  
 Gibbs, Willard 131  
 Penney, William 27  
 Wind Water Sun 216  
 WO<sub>3</sub> 173, 209–11  
 WO<sub>3</sub> varistors 210  
 Work function W1 174  
 World War I 60
- X**  
 Xenon Xe 16  
 XPS (X-ray photoelectron spectroscopy) 34, 57, 66–67, 71  
 XPS method 66  
 XPS survey spectrum 67  
 XPS X-ray photoelectric spectroscopy 71  
 X-ray analysis 140  
 X-ray crystallography 60  
 X-ray diffraction  
 X-ray diffraction analysis 60  
 X-ray diffraction patterns for crystal structure 81  
 X-ray diffractometers 60, 65  
 X-ray gun 67  
 X-ray lithography position 108  
 X-ray of wavelength 71  
 X-ray photo-electron spectroscopy 67  
*see also* XPS (X-ray photoelectron spectroscopy)  
 X-ray reflectivity 60  
 X-rays 57–61, 63, 65–67, 71, 103  
 X-rays for chemical analysis 64  
 X-ray spectrometer 65  
 X-rays secondary 63  
 X-ray tool 61  
 XRD (X-ray diffraction) 14, 39, 57, 60–61, 71, 81  
 XRD, short wavelength X-rays 60  
 XRD diffractometer 60  
 XRD method of characterizing materials 60  
 XRD pattern 61–62, 71
- Y**  
 YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7</sub> 18  
 YAG 52, 252  
 Y-Al-garnet 52  
 Yamada, Y. 213  
 Yang, Chen Ning 95  
 Yatria 209  
 Yatria stabilized zirconia (YSZ) 209, 225  
 YBaCu-oxide 83  
 YBCO 18, 21, 41, 83  
 YBCO in superconducting state 21  
 YBCO sample 21  
 YbMnO<sub>3</sub> 103  
 YIG 51  
 Yin, L. 214  
 YMnO<sub>3</sub> 103  
 Yousafzai, Malala xiii  
 Y-Sc-Ga garnet 52  
 YSGG 52  
 YSZ (Yatria stabilized zirconia) 209, 225
- Z**  
 Zeeman Effect 11  
 Zehnder interferometer 252  
 Zepf, V. 216, 228  
 Zhang, L. 214  
 Zhong, Jian 112–13, 120, 151  
 Ziman model 27  
 Zinc (Zn) 17, 84, 86, 234

- Zinc oxide (ZnO) 42, 53, 84, 113,  
154–55, 173, 179–81, 184–86,  
209–11, 242, 251
- Zinc sulfide (ZnS) 17, 53, 83–84, 156,  
254
- Zirconate titanate  $\text{PbZr}_x\text{Ti}_{1-x}\text{O}_3$  140
- Zn atom 84
- Zn ferrite 232
- $\text{ZnCr}_2\text{O}_4$  207
- $\text{ZnCr}_2\text{Se}_4$  103
- $\text{ZnFe}_2\text{O}_4$  235
- Zn-ferrites 233, 235
- Zn-ferrite Soft 239
- Zn-ferrites Soft Used 239
- ZnO and  $\text{SnO}_2$  varistors 210
- ZnO-based homogeneous 183
- ZnS crystal 255
- ZnO grain 189
- ZnO matrix 185–86
- ZnO substrates 183
- ZnO varistor in comparison 185
- ZnO varistors 184–87, 189–90
- ZnO varistors for high-voltage  
applications 185
- ZnSe 17, 182
- ZnTe 17
- Zr 81, 131
- $\text{ZrO}_2$  225
- $\text{Zr}_{0.2}\text{Ti}_{0.8}$  103
- Zürich 64







