

# Subject Index

- 3 dB loss 4, 333, 446  
4 × 4 matrix method 526–533  
    Berreman's 532  
4-(trans-4-Pentylcyclohexyl)benzointrile  
    23  
5CB  
    also see K15 16, 17, 18, 23, 102  
    index of refraction 102  
5OCB  
    also see M15 23, 102  
    index of refraction 102  
6CB 15, 16  
7CB  
    also see K21 23, 102  
    index of refraction 102  
7OCB  
    also see M21 23, 102  
    index of refraction 102  
8OCB  
    also see M24 23, 102  
    index of refraction 102  
90-degree TN-LC 211
- Absorption axis (polarizer) 3, 4, 8,  
    126–129, 252, 253, 317, 320–322, 332,  
    348, 363, 524, 572–574, 590, 593,  
    598–600, 607, 609, 610, 612, 625, 634,  
    636, 638, 640, 642  
Achromatic line  
    conoscopy 233  
Achromatic wave plate 199, **254–264**,  
    265–268, 272, 276, 287, 289, 613, 714,  
    716–720  
Acrylate  
    index of refraction 104  
Acrylic  
    index of refraction 104
- Active matrix (AM) 2, 290, 426, **430**,  
    431, 457, 570  
Active matrix (AM) displays 430–446  
Addition of colors  
    CIE 1976 color space 452–457  
Adhesion of LC molecules 28  
Adiabatic following  
    in TN-LC 208, 210, 211, 212, 214, 478,  
    484  
ADP  
    index of refraction 101, 262  
Ag<sub>3</sub>AsS<sub>3</sub>  
    index of refraction 101  
AgGaS<sub>2</sub>  
    specific rotatory power 140  
Aragonite  
    index of refraction 161  
Aero and textured polymers  
    index of refraction 104  
Air  
    index of refraction 104  
Al<sub>2</sub>O<sub>3</sub>  
    index of refraction 101  
Aligned ellipsoids  
    composite media 662  
Alignment layer 6, 24, 28, 291, 403, 408,  
    409, 414, 431, 434, 579, 581, 589, 592,  
    660  
Alkenyl 17  
Alkenyl chain 17  
Alkoxy 17  
Alkoxy chain 17  
Alkyl 17  
Alkyl chain 17  
AM (active matrix) displays 430–446  
AM-LCD module  
    schematic drawing 433

- Amorphous-Si TFT (a-Si TFT) 433, 434, 437, 440, 441, 443, 444
- Analytic representation 55, 86
- Analyzer 197–205, 207, 214, 234, 284, 292, 321, 322, 333, 336, 338, 375–381, 433, 446, 449, 615
- Anchoring of rodlike LC molecules 28, 317
- Angle of incidence 115, 116, 123, 127, 130, 132, 133, 162, 165, 185, 224, 226–230, 232, 233, 242, 246, 250, 251, 269, 270, 272, 274, 280, 288, 300, 301, 321, 323, 324, 347, 354, 406, 494, 503, 504, 507, 568, 582, 597, 599–602, 606, 672
- Angular aperture 4, 276
- Angular frequency 55
- Angular momentum  
of circularly polarized light 78  
of elliptically polarized light 79  
of photon 58
- Anisotropic 3, 15, 25, **82–172**, 173, 178, 181, 208, 225, 229, 297, 342, 422, 462, 488, 517, 526, 527, 529–534, 538, 541, 544, 545, 554, 562, 565, 567, 597, 659, 666
- Anisotropic absorption 126
- Anisotropic layered media 562
- Anisotropic media (propagation) 82
- Anisotropic media (power flow) 100, 104
- Anisotropic molecules 15, 82
- Anisotropy of the boundary 6
- Antisymmetric tensor 143, 145, 166
- Aperture ratio 438, 440, 448, 449
- a-plate 199, 201–203, 225, 227–231, 245–246, 252, 254, 269, 272, 277, 283, 288, 298, 389, 499–501, 507  
compensator 582, 589, 590, 593, 607–610, 615–618, 621, 622, 625, 636, 638, 648, 651, 652, 653, 655, 656, 659, 666
- Arbitrary c-axis orientation 486, **505**
- Ardel  
index of refraction 104
- Aromatic ester  
index of refraction 103
- Aromatic systems 21
- Array fabrication (TFT) 440
- a-Si TFT 433, 434, 437, 440, 441, 443, 444
- Atomic polarizability 724
- Attenuation 126, 127, 130, 195, 279, 400, 401, 554, 598, 673
- Attenuation coefficient  
Mie scattering 733, 737, 739  
PD-LCD 402, 403
- Averaged polarizability tensor 667
- Azimuth angle (of angle of incidence) 185, 244, 300
- Azimuth angle (of LC director) 20, 215  
in TN-LC 208, 215
- Azimuth angle (of polarizer) 215, 217, 218, 375
- Azimuth angle (of polarization ellipse) 62, 63, 214, 222
- Azimuth angle (of slow axis) 74, **174**
- Azobenzene 17
- Azoxy  
index of refraction 102, 103
- Backlight 2, 9–12, **14**, 15, 47, 235, 407, 408, 433, 447–449, 452, 456, 571, 606, 607, 609–611, 616, 621, 622, 624, 626, 721
- BA-LCD 394, 396, 407, 419, 425
- Bandgap  
in CLC 467, 468, 476, 477, 481, 483
- Barium sulfate 13, 739
- Barium titanate  
index of refraction 101
- $\beta$ -BaB<sub>2</sub>O<sub>4</sub>  
index of refraction 101
- BaTiO<sub>3</sub>  
index of refraction 101
- BBO  
index of refraction 101
- BCB  
index of refraction 104
- BCH-5 16
- BDH, Ltd.  
liquid crystal 102, 103
- BEF, see Brightness enhancement film
- Be<sub>3</sub>Al<sub>2</sub>(SiO<sub>3</sub>)<sub>6</sub>  
index of refraction 101
- Beckers achromatic wave plate 260–264
- Bend 26, 47, 50, 395, 676
- Bend aligned cells 389, 394, 395, 397

- Bend cell 29  
Bend elastic constant 26, 37, 41, 374, 679  
Bend-aligned (BA) cells 389, 394, 395, 397  
Bend state 395, 396  
Benzene rings 15, 16, 25  
Benzocyclobutene (BCB)  
  index of refraction 104  
Benzonitrile 16  
BeO  
  index of refraction 101  
Berreman's  $4 \times 4$  matrix 532  
Beryl  
  index of refraction 101  
Beryllium oxide  
  index of refraction 101  
Bias ratio 429, 430  
Biaxial 25, 97–99, 101, 121, 124, 173, 228, 233, 234, 273, 285, 413, 517, 522, 533, 542  
Biaxial compensator 571, 606, 611, 612, 623, 624, 625, 642, **654–658**, 659, 663, 669, 670  
Biaxial media  
  light propagation **151–162**, 164, 170–172  
Biaxial media (negative) 160–161  
Biaxial media (neutral) 160  
Biaxial media (positive) 160–161  
Biaxial plate (modes of propagation) 247  
Biaxial plate (phase retardation) **242–254**, 270  
Bicyclohexane 25  
Bidirectional alignment  
  rodlike molecules 668, 669  
Binary mixture 18  
Biphenyl 17  
Biphenylcyclohexane 16, 23  
Birefringence 3, 4, 7, 8, 16–18, 24, 25, 76, 112, 126, 147, 150, 176, 201, 210, 211, 219, 220, 223, 226, 230, 254, 260–264, 271–273, 275, 280, 288, 289, 291, 298, 322, 329, 335, 342, 381, 389, 396, 419, 461, 464, 465, 470, 479, 480, 481, 484, 488, 495, 496, 497, 499, 502, 505, 507, 509, 516, 522, 567  
  definition 24–25  
Birefringence compensation 570, 605, 614, 615  
Birefringent thin film compensator 7  
Birefringent plate  
  between crossed polarizers 202, 204  
  between parallel polarizers 201, 204  
BK  
  index of refraction 104  
BK-7  
  index of refraction 104  
Black body radiation 307, 309, 339, 356  
Black matrix 8, 9, 431, 433, 434, 448  
Bloch waves  
  in CLC 465, 467, 479  
Bloch-Floquet theorem 465  
BLU (Back Light Unit)  
  see Backlight  
Blue mode  
  STN-LCD 380  
Buffing 320, 438, 572, 573  
Borosilicate (BK)  
  index of refraction 104  
Bottom gate structure  
  TFT 440, 442, 443  
Bragg condition  
  in CLC 472, 473, 477  
Bragg reflection  
  in cholesteric LCD 416  
  in CLC 461, 462  
  periodic birefringent 138  
Bragg regime 461, 467, 470, 479  
  coupled mode analysis 471  
Brewster angle 115, 116, 120, 501, 504  
Brightness 9–12, 14, 15  
Brightness enhancement film (BEF) 9  
Broadband quasi-circular polarizer 264–269  
Brushes  
  conoscopy 233, 285  
Butyrate  
  index of refraction 104  
C  
  index of refraction 101  
 $C_2H_2$  17  
 $C_2H_4$  17  
CAB  
  index of refraction 104

- CaCO<sub>3</sub>  
 index of refraction 101
- CaF<sub>2</sub>  
 index of refraction 101, 104
- Calcite  
 index of refraction 101
- Carbon disulfide (CS<sub>2</sub>)  
 Verdet constant 150
- Cathode ray tubes (CRT) 1
- CCH-501 16
- CdS  
 index of refraction 101
- CdSe  
 TFT 440, 441, 445, 446
- CdTe  
 index of refraction 101
- CEC  
 specific rotatory power 141
- CEEC  
 specific rotatory power 141
- Cell assembly  
 TFT-LCD 445
- Cellulose acetate butyrate (CAB)  
 index of refraction 104
- Chebyshev's identity 209, 282
- Chemical bond 25, 27
- Chiral dopant 369
- Chiral molecules 18, 30, 139, 143, 369,  
 370, 374, 702, 703
- Chiral nematic 368, 369
- Chirality  
 molecular 30, 413, 414, 461, 462, 702
- Cholesteric LCD 291, 412, **416–417**, 419
- Cholesteric liquid crystal (CLC) 138,  
 196, 215, 413, 416  
 dielectric tensor **462**  
 optical properties **461**  
 polarizer 447
- Cholesteric phase 18, 19, 20, 369
- Cholesteryl benzoate 15
- Cholesteryl 2-2-ethoxy-ethoxy ethyl  
 carbonate  
 specific rotatory power 141
- Cholesteryl chloride mixture  
 specific rotatory power 141
- Cholesteryl ethyl carbonate  
 specific rotatory power 141
- Cholesteryl oleyl carbonate  
 specific rotatory power 141
- Chroma difference  
 CIE 1976 457
- Chromatic dispersion 22, 55, 84, 87, 89,  
 101, 143, 254, 260
- Chromaticity coordinate 451, 452, 454,  
 456, 457, 459, 460
- Chromaticity diagram  
 CIE 1964 455
- Chromaticity difference  
 CIE 1976 457  
 CIE 1931 452  
 CIE 1964 452, 455  
 chromaticity diagram 455  
 CIE 1976  
 color space 452, 456, 457  
 chroma difference 457  
 chromaticity difference 457  
 color difference 457  
 hue angle 456  
 hue angle difference 457  
 metric chroma 456  
 metric lightness 456  
 redness-greenness 456  
 saturation 456  
 yellowness-blueness 456
- CIE daylight illuminant D65 311, 339
- Cinnabar 140
- Circular birefringence (double  
 refraction) 140, 143, 150, 470, 479
- Circular form birefringence 461
- Circular polarization state 57
- Circular polarizer 194–199, 555
- Circular regime  
 in CLC 470, **479**
- Classification of biaxial crystals 160
- Classification of media 97
- CLC (cholesteric liquid crystal)  
 Bragg regime 467, 470, 471  
 circular regime 470, 479  
 dielectric tensor 462  
 dispersion relation 466  
 Mauguin regime 468, **477**  
 power orthogonality 471  
 reflectance of CLCs 475
- CLC polarizers 447, 448
- Clearing point 17, 18, 20, 21, 22
- COC 104, 141, 659  
 index of refraction 104  
 specific rotatory power 141

- Cold cathode fluorescence lamp (CCFL) 10–14
- Colorant 9
- Color instability 7
- Color compensation 381
- Color desaturation 456, 649
- Color difference  
CIE 1976 457
- Color filters **8**, 410, 411, 431, 433, 445, **448**, 449
- Color matching functions 452  
spectrum 455  
values of (table) 453
- Color pigment 8, 9, 47, 451
- Color purity 9, 14
- Color saturation 14
- Colored ink 448
- Colors  
addition of 452
- Colors in LCD 426, **450**
- Column driver 430, 444, 445
- Compensator  
biaxial 571, 606, 611, 612, 623, 624, 625, 642, **654–658**, 659, 663, 669, 670  
negative c-plate 605, 606  
negative TN-LC 627–630  
polarization 614, 615, 616  
o-plate 648, 651–655, 659, 660  
sixth-wave plate 607
- Compensator material 659
- Compensators for LCDs 570, 595, 605, 614
- Complex number representation 61
- Conical refraction 152, 153, 164
- Conoscopy 229  
a-plate of uniaxial crystals 229  
c-cut biaxial plate 233  
c-plate of uniaxial crystals 231
- Conservation of angular momentum 150
- Conservation of energy 186, 540, 546, 550, 722, 736
- Conservation of power flow 168
- Constitutive equations 83
- Contrast at normal incidence  
definition 299, 344–346, 384
- Contrast ratio  
definition 304, 308, 353, 355–356, 605  
PD-LCD 400
- Coordinate rotation 58, 153, 164, 174, 248, 249, 320, 423, 464, 497, 498
- Coordinate rotation matrix 174, 176, 209, 463, 481, 494, 502, 518, 550, 559
- COP 104, 659  
index of refraction 104
- Coplanar structure  
TFT 440–441, 443
- Cosine rule 712
- Coupled mode analysis  
Bragg regime in CLC 471
- c-plate  
conoscopy 231  
definition 122  
compensator 605–606  
phase retardation 228
- Critical field  
IPS cell 39, 692  
parallel aligned cell 34, 684  
twisted nematic cell 39  
vertical aligned cell 37, 686
- Critical voltage  
in plane switching cell 39  
parallel aligned cell 34, 683, 684, 700  
vertical aligned cell 37, 686  
TN-LC 39, 701, 708  
STN-LC 708
- Cross reflection coefficients 491, 492, 568
- Cross section  
Mie scattering 400–402, 722, 723, 725, 726, 728, 729–734, 736, 739, 740
- Crossed a-plates 666
- Crossed polarizers  
field-of-view 128  
leakage of light 129, 130, 169, 571, 596, 598  
transmission 128, 169  
with extended Jones matrix 502
- Crystal-Si TFT 440
- c-Si TFT 440
- Cubic (crystal system) 98, 99, 148
- Current density 83, 85
- Curvature elasticity 26
- Curvature strain tensor 26
- Cyanide group 22
- Cyano 25

- Cyano terminal group (CN) 25  
 Cyanoalkoxybiphenyl  
   index of refraction 102  
 Cyanoalkylbiphenyl  
   index of refraction 102  
 Cyanobiphenyl  
   index of refraction 103  
 Cyanophenyl  
   index of refraction 103  
 Cyanoterphenyl  
   index of refraction 103  
 Cyclic olefin  
   index of refraction 104  
 Cyclohexane 16, 21, 25  
   index of refraction 103  
 Cyclohexyl 16  
 Cyclotene  
   index of refraction 104  
 Cocolac 13
- d/p ratio 371–373, **374**  
 D65 311, 339  
 Dangling bond 28  
 Data line 433, 434, 440, 443  
 Daylight white 460  
 Debye theory of polar molecules 22, 24  
 Decay time **39–46**  
   IPS cell 41  
   PA cell 40  
   TN cell 42  
   VA cell 41  
 Degree of order 20  
 Degree of depolarization 559  
 Degree of polarization 66, 67, 81, 546,  
   556, 557, 562  
 Delocalized electrons 16, 25  
 Depolarization factor 663  
   of ellipsoid 709  
 Dextro- 139  
 Dextrorotatory 140  
 Diamond  
   index of refraction 101  
   Verdet constant 150  
 Dichroic crystal 3, 126, 127, 133  
 Dichroic filter 419  
 Dichroic mirror 411  
 Dichroic polarizers 126, 127, 133, 165  
 Dichroic ratio 3, 17  
 Dichroism 3, 4
- Dielectric anisotropy 6, 7, 16–18, 22, 30,  
   31, 33, 34, 36, 37, 325, 339, 340, 438,  
   464, 474, 589, 683, 684, 686, 692, 698,  
   705  
   definition of 21  
   negative 24, 36, 293, 294, 330, 579, 580,  
   581, 684, 687  
   positive 6, 22, 24, 330, 591, 684, 690  
   range 22  
 Dielectric constants 17, 18, **21**, 22, 24, 25,  
   84, 85, 87, 134, 166, 294, 340, 373,  
   393, 462, 463, 471, 565, 678, 679, 695,  
   696, 721, 725  
 Dielectric constant  
   effective 134–136  
   principal 84, 518, 520, 563, 704  
   table 23  
 Dielectric tensor 32, 53, **82–85**, 90, 98, 99,  
   143, 144, 154, 166, 413, 422, 518, 519,  
   523, 524, 533, 537, 566, 689  
   effective 136  
   CLC 461–465, 471, 474, 481  
   symmetry of 84, 170  
 Diffuser 2, 10, 11, **12–14**, 571, **721**, 723,  
   728, 731–736, 738–740  
 Diffusive reflector 241, **735–740**  
 Diphenyldiacetylene 25  
 Diphenylethane  
   see C2H4 17  
 Dipolar interaction 27  
 Dipole moment 21, 22, 31, 49, 143,  
   150, 413, 414, 680, 690, 709, 710,  
   725  
 Dirac notation 207, 208, 287  
 Director 18, **20**, 21, 22, 24, 26–33, 35–41,  
   49, 50, 53, 76, 82, 173, 208, 210–217,  
   219, 222, 223, 235–237, 240, 241, 277,  
   283–285  
 Director distribution  
   BA cell 395  
   IPS-LCD 327  
   N-LCD 393  
   Parallel aligned cell 36  
   STN-LCD 383, 702, 703, 706  
   TN-LCD 341, 694, 701  
   VA-LCD 38, 292, 295  
 Discotic 127, 571, 659  
 Disinclination 27  
 Dispersion relationship 113, 461

- Dispersion relation  
in CLC 461, 465, **466**
- Displacement field vector 21, 83, 84, 92, 150
- Displacement vectors  
of E wave 108  
of O wave 108, 129
- Distribution instability 296, 341
- Domain boundaries 20, 24
- Domain 15, 20, 24, 27, 29, 291, 314, 315, 316, 373, 398, 416
- Double bond 17
- Double refraction 3, 82, 115, 119, 124, 125, 165, 226, 242
- Double refraction (circular) 140, 143
- Double refraction at a boundary  
**112**–125, 140
- Drain (FET) 434, 435, 436, 438, 440–445, 459
- Dual frequency material 24, 46, 47
- Dual scan 430
- Dyad 206
- Dye filter 8
- Dyed gelatin 448
- Dyed polyimide 445, 448
- Dynamic coupling condition  
in CLC 472
- Dynamic matrix  
 $4 \times 4$  528, 529  
extended Jones 494, 497, 498, 507–511, 517, 521, 522
- Dynamics (of molecular rotation) 39
- E mode  
in TN-LC 210–212, 320, 333–335, 360, 363–365, 371, 425, 572–574
- E wave 107–110, 124, 127, 499, 670
- E5 23  
index of refraction 103
- E7 23, 501  
index of refraction 103
- E8  
index of refraction 103
- EBBA 16, 18
- ECB-LCD 291, 391
- Effective dielectric constant 134–137
- Effective index 137, 398, 399, 664, 710
- Effective principal refractive index  
form birefringence 662, 669, 670, 710
- Eigen refractive index 100, 107, 118, 144, 151, 155, 157, 158, 170, 208, 225, 226
- Eigenmode 93, 94, 106, 111, 112, 115, 145, 146, 154, 168, 511, 521, 522  
in optically active media 146
- Eigenstate (polarization) 204
- Eigenvalue 90, 92, 146, 154, 156, 159, 168, 186, 218, 219, 281, 520, 545, 546, 717, 718
- Eigenvector 90, 156–159, 164, 168, 186–188, 219, 281, 522, 545, 717, 718
- Eigenvector of Jones matrix 186–188
- Eigenpolarization 163, 517, 527
- Elastic constant 16–18, **26**, 27, 34, 37, 39–42, 47, 294, 325, 339, 370, 372, 374, 392, 414, 674, 679  
tables 23
- Elastic energy density 26, 29, 32, 33, 294, 395, **674**, 675  
IPS cells 324  
STN cells 370, 371, 374, 381, **702**  
tilt mode 32, 33, 294, 395, 676, **680**  
TN cell 339, 424, **694**  
twist and tilt mode 677  
twist mode 324, 676, **689**  
VA cell 392
- Elastic restoring torque 26, 31, 33, 36, 45, 46, 680, 743
- Elasticity 26, 28, 48
- Electric charge density 83, 85, 422, 678
- Electric torque (or electrostatic torque)  
21, 26, 29–34, 37, 44–46, 51, 324, 330, 680, 684, 690, 743, 744
- Electrical conductivity 5, 434, 435, 437
- Electrically controlled birefringence (ECB) 291, 391
- Electrodistortion 290, 324, 367, 372, 384  
IPS mode 324, 592  
VA 392, 582  
STN or TN 367, 371–374, 384, 387, 575
- Electroluminescence (EL) 1, 14
- Electromagnetic energy 32, 152, 153
- Electromagnetic energy density 32, 325, **674**, 678, 690, 695, 704
- Electro-optical effect 21, 29, **30**,

- Electro-Optical Distortion 674, 675  
   tilt mode 680–688  
   TN-LC 694–701  
   twist mode 689–693  
   STN-LC 702–708  
   VA-LC 684–688
- Electrostatic energy 7, 30, 31, 36, 49, 294, 295, 341, 365, 374, 382, 392, 422, 579–581, 589, 591, 674, 681
- Electrostatic energy density 21, 49, 50, 53, 294, 330, 339, 381, **677**, 678, 680, 684
- Electrostatic torque 29–34, 37, 44–46, 51, 324, 330, 680, 684, 690, 743, 744
- Elliptic Polarization States **56–60**, 62, 64, 67–69, 73–76, 78–81, 128, 143, 146, 169, 179, 187, 190, 211, 218, 219, 221, 282, 284, 335, 377, 466, 468, 482, 588, 596, 598, 602, 603, 613, 644
- Ellipticity **59**, 69, 81, 146, 147, 168, 199, 266, 267, 285, 335, 346, 663  
   in TN-LC 214, 215, 283, 422  
   of modes in CLC 468, 470, 477–479, 482
- Ellipticity angle **62**, 68, 74, 75, 79
- Elongated molecules 15
- EM-Merck  
   liquid crystal 102
- Enantiotropic cholesteryl chloride  
   specific rotatory power 141
- eo-coordinate system 210, 218, 219, 223, 283, 284
- Equi-energy white light 460
- Equivalent circuit 268, 269  
   birefringent network **190**, 192, 281, 282  
   of reflective LCD 406
- E-type polarizer 126, 127, 130, 597, 598, 665, 673
- Eutectic 18
- Eutectic point 18
- Evans K parameter 270, 271
- E-wave excitation 233, 491
- Excitation of te mode 284
- Excitation of to mode 284
- Existence of linearly polarized input/output states  
   general birefringent network 189, 192, 282
- Extended Jones matrix method 162, 232, 233, 300, 304, 331, 347, 352, **485–526**, 608, 613, 617, 623, 624, 626, 630, 665
- Extinction coefficient 126
- Extinction ratio 3, 4, **127**, **128**, 133, 299, 304, 346, 598
- Extraordinary polarization 3, 403, 506, 509, 511, 597
- Extraordinary refractive index 24, 25, 100, 111, 126, 127, 269, 280, 403, 510, 523
- Extraordinary wave 107, 110, 111, 115, 118–120, 124, 126, 129, 138, 158, 173, 225, 226, 233, 253, 261, 280, 317, 320, 321, 333, 363, 485, 487, 488, 491, 493, 499, 505, 506, 520, 572, 598, 599, 602, 603, 606, 607, 609, 610, 663, 673  
   group velocity 163
- Fabrication process  
   TFT array 440
- Fabry-Perot cavity 5
- Fabry-Perot effect 174, 486, 530
- Faraday rotation 76, **139**, **149**, 517, 532
- Fast axis **70**, 71, 173, 174, 192, 210
- Feldspar  
   index of refraction 101
- Ferroelectric LCD 291, **412**, 414, 415, 421
- FET, see Field effect transistor
- FFS-LCD 330, 331
- Field effect transistor (FET) 12, 436
- Field emission devices 1
- Field-induced director reorientation  
   IPS-LCD 324  
   STN-LCD 382  
   TN-LCD 339  
   VA-LCD 294
- Field-induced distortion **30**, 36, 37  
   VA cell 38
- Field-of-View  
   crossed polarizers 128
- Field-sequential color 417
- Fluorite  
   index of refraction 101  
   Verdet constant 150
- Focal conic state (FC)  
   in cholesteric LCD 416, 417

- Form birefringence 4, 461, 659, **660**, 709  
 compensator 571  
 in layered media 660, 662, 669, 670  
 of composite media 662, 709
- Form dichroism 4
- Frame rate 17, 39, 41, 417
- Free energy 26, 581, 660, **681**, **690**, **696**, 697, **704**, 705, 743
- Fresnel 140
- Fresnel equation 94, 144, 155, 163, 242
- Fresnel equation of wave normals 92, 171
- Fresnel reflection 174, 485, 486, 512
- Fresnel reflection coefficient 496
- Fresnel transmission coefficient 490, 497, 502, 508, 509, 521
- Fringing field switching (FFS) 330
- GaAs  
 index of refraction 101
- GaP  
 index of refraction 101
- Gate (FET) 434, 435, **436**, 438, 440–445, 459
- Gate line 431, 433, 434
- Ge  
 index of refraction 101
- General TN-LCD  
 transmission properties 215
- Generalized Jones matrix method 517
- Geodesic distance 609, 610, 712
- Geodesic triangle 77, 78
- Glan prism 165
- Glass (crown)  
 Verdet constant 150
- Glass (flint)  
 Verdet constant 150
- Grandjean zone 374
- Group velocity 89, 108, 152, 163, 467, 480, 520
- Gypsum  
 index of refraction 101
- Gyration tensor 145, 147, 167  
 table 148
- Gyration vector 143, 144, 149
- H<sub>2</sub>O  
 index of refraction 101
- Half-wave plate 71, 110, 165, 178, 192, 194, 203, 240, 254–260, 262–268, 271, 272, 276, 277, 287, 289, 293, 298, 391, 409, 606, 718, 719, 720  
 effect on polarization state 73–76, 179  
 Jones matrix 178, 555
- Half-wave retardation plate 44, 73, 178
- Hard glass 441, 443
- Helical axis 18, 19, 127, 368, 413, 416, 461–463, 465, 471
- Helical structure (Helix) 127, 139, 369, 413, 414, 416, 461–463, 702
- Helicity 58, 79
- Heptylcyanobiphenyl 16
- Heptyloxycyanobiphenyl 16
- Herapathite 126
- Hermitian 105, 144, 145, 166, 168, 177, 184, 200, 278, 547
- Hexagonal 16, 98, 148
- Hexagonal (crystal system) 98, 148
- Hexylcyanobiphenyl (6CB) 15
- HN22  
 polarizer 446
- HN32  
 polarizer 446
- HN38S  
 polarizer 446
- HN42HE  
 polarizer 446
- Homeotropic alignment 28, 240, 293, 334, 346, 381, 382, 387, 391–393, 396, 406
- Homeotropic state  
 in cholesteric LCD 416, 417
- Horizontal viewing 301, 397, 398, 425, 632  
 IPS-LCD 594, 595, 644  
 VA-LCD 302, 308, 312, 634, 636, 638, 640, 642  
 STN-LCD 388, 582, 584, 585  
 TN-LCD 348, 349, 350, 354, 356–359, 576, 578, 579, 586, 588, 645–647, 649, 652–654, 656–658
- Hue angle  
 CIE 1976 456

- Hue angle difference  
 CIE 1976 457
- Human eyes  
 photopic response 306, 310, 339, 450, 451
- Hydrogen 16, 279a
- Hydrogen bonding 27
- Hydrogen H $\alpha$ -line 279
- Ice  
 index of refraction 101
- Illuminance 10, 11
- Illuminant spectral distribution 306, 309, 311, 339, 356
- Imaginary isotropic layer 509, 510, 521, 522
- Impermeability tensor 145, 154, 156–158
- Incompressible fluid 26
- Index ellipsoid 154–157, 247, 248, 615
- Index mismatch 5
- Index of refraction 5, 12, **24**, **55**, 71, 84, **87**, 92, 100, 109, 111, 113, 118–130, 137, 138, 151, 158, 225, 226, 254, 321, 400, 401, 403, 477, 492, 496, 499, 509, 511, 521, 545, 599, 600, 726, 728  
 complex 126, 127, 134, 502, 524, 673  
 tables 23, 101–104, 161
- Indium oxide 5
- Indium tin oxide (ITO) 1, 5, 291, 333, 408, 431, 433, 434, 438, 440–445, 448, 449, 530
- Induced dipole moment 21, 22, 31, 49, 143, 150, 709, 710, 724, 725
- InP  
 index of refraction 101
- In-plane alignment 296
- In-plane retardance 161
- In-plane switching (IPS) 290, **316**, 319–331  
 threshold voltage 39
- Intensity transmission spectrum 199–208
- Intermolecular forces 16, 27, 399
- Inverted staggered structure  
 TFT 440–441, 445
- Iodine 3, 126, 127, 162, 446, 597
- Iodoquinine sulphate 126
- IPS (in plane switching) 290, **316**, 319–331
- IPS-LCD 316–331
- Irradiance 10
- Iron law of multiplexing 428
- Isochromatic line  
 conoscopy 231, 232, 233
- Isothermal deformation 26,
- Isotropic 20, 54, 55, 70, 77, 83, **84**, 85–88, 98–101, 104, 112, 113, 115, 117–122, 124, 134, 138, 146, 149, 163, 186, 200, 244, 398, 399, 401, 486, 487, 509, 517, 521, 531, 533, 540, 543–545, 562, 566, 571, 612, 659, 660, 669, 672, 709, 710, 734
- ITO (indium tin oxide) 1, 5, 291, 333, 408, 431, 433, 434, 438, 440–445, 448, 449, 530
- Jones matrix **173–289**, 297, 300, 304, 318, 327, 331, 335, 342, 347, 352, 382, 383, 398, 404, 406, 407, 425, 478  
 general properties 179  
 table 193, 194, 554, 555
- Jones vector **62–64**, 69, 79, 142, 146, 174, 176–179, 182, 186–188, 195, 200, 210, 211, 214, 216, 218, 220, 236, 278, 284, 335, 336, 407, 472, 473, 478, 483  
 table 65, 175
- K15 23, 103
- K15 (5CB), Cyanoalkylbiphenyl  
 index of refraction 23, 102
- K21 23, 103
- K21 (7CB), Cyanoalkylbiphenyl  
 index of refraction 23, 102
- Kapton  
 index of refraction 104
- KDP  
 index of refraction 101
- KH<sub>2</sub>PO<sub>4</sub>  
 index of refraction 101
- Kinematic condition  
 refraction and reflection 113, 115, 117, 118
- Lambertian 13, 53
- Laser annealing  
 p-Si TFT 444
- Latitude  
 Poincaré sphere 69

- Law of multiplexing 384, 428  
 LBO ( $\text{LiB}_3\text{O}_5$ )  
   index of refraction 161  
 LCOS, see Liquid crystal on silicon  
 LED, see Light emitting diode  
 Lenz law 143  
 Levo- 139  
 Levorotatory 140  
 Lexan  
   index of refraction 104  
 Light emitting diode (LED) 1, 10, 12–14,  
   419, 421, 734, 735  
 Light guide  
   see Waveguide  
 Light propagation in biaxial media  
   151–162  
 Light propagation in uniaxial media  
   107–112  
 $\text{LiNbO}_3$   
   index of refraction 101  
 Linear Polarization States 56  
 Linearly polarized input/output 188–190  
 Linking group 15, 17  
 Liquid crystal director  
   see Director  
 Liquid crystal materials  
   table of 16, 23  
 Liquid crystal molecular structure 15–18  
 Liquid crystal on silicon (LCOS)  
   417–419  
 Liquid crystal phases 18  
 Liquid crystal  
   optical symmetry, table 99  
 $\text{LiTaO}_4$   
   index of refraction 101  
 Lithium Niobate  
   index of refraction 101  
 Local principal coordinate 210, 211, 214,  
   218, 219, 462, 468, 478, 482, 483, 522  
 Long range order 20  
 Long range orientational order 18  
 Long wavelength circular regime  
   in CLC 470  
 Longitudinal polarizability 22, 49, 667  
 Lorentz reciprocity theorem **89**, 94, 564  
 Low pressure chemical vapor deposition  
   443  
 Low temperature devices  
   TFT 443  
 Lower twisted nematic (LTN) 215  
 LPCVD 443  
 LTN-LCD 215  
 Lucite  
   index of refraction 104  
 Luminance 10–12, 53, 299, 306–308, 338,  
   339, 346, 355, 356, 456, 457  
 Lyot (wide field element) 271–276,  
   288  
 Lyot-Ohman filter 279, 281  
 M15 23, 102, 103  
 M15 (5OCB), PentyloxyCyanobiphenyl  
   index of refraction 23, 102  
 M21 23, 102, 103  
 M21 (7OCB), HeptyloxyCyanobiphenyl  
   index of refraction 23, 102  
 M24 23, 102, 103  
 M24 (8OCB), OctyloxyCyanobiphenyl  
   index of refraction 23, 102  
 Magnetic induction 83  
 Magnetogyration coefficient 149  
 Material equations 82, **83**, 143  
 Matrix addressing 426  
 Mauguin condition 335–337  
 Mauguin parameter 212, 219, 236–238,  
   240, 241, 283, 336, 376, 411, 424,  
   451  
 Mauguin regime 220, 283, 377  
   in CLC 461, **468**, **477**, 478, 479, 483,  
   484  
 Maxwell equations **82**, **83**, 85, 87, 88, 89,  
   90, 92, 105, 140, 166, 488, 527, 532,  
   538, 689, 695  
 MBBA 16, 18, 22, 23, 102  
   Verdet constant 150  
 MBBA (Schiff base)  
   index of refraction 23, 102  
 Melting point 17, 18  
 Merck  
   liquid crystal 44, 102, 103  
 Meridian  
   Poincaré sphere 68, 69  
 Metal oxide filter 8  
 Metal oxide semiconductor FET 436  
 Metric chroma  
   CIE 1976 456  
 Metric lightness  
   CIE 1976 456

- MgF<sub>2</sub>  
   index of refraction 101  
 Mica 101, 154, 161, 164  
   index of refraction 101, 161  
 Microprism 10, 11, 734  
 Mid-layer tilt angle 296, 297, 341, 342,  
   372, 383, 387, 393, 574–576, 582, 585,  
   649–651, 682–688, 697, 698, 700, 701,  
   706, 707  
 Mid-layer twist angle 325, 326, 592, 593,  
   691, 692  
 Mie scattering 400, 420, **721**  
 Milky fluid 20, 24, 398  
 Mirror reflection 179, 182, 184, 185, 241,  
   407, 413, 414, 715, 716  
 Mixed mode operation  
   TN-LCD 284  
 Mixing of Colors  
   CIE 1976 color space 452  
 MLC-2408 24, 46  
 MLC-6608  
   index of refraction 23, 103  
 MLC-6610  
   index of refraction 23, 103  
 MLC-6682  
   index of refraction 23  
 MLC-6685  
   index of refraction 103  
 MLC-6686 23, 36, 38, 44, 45, 52, 103,  
   295  
   index of refraction 23, 103  
 MLC-7026  
   index of refraction 23  
 MLC-7029  
   index of refraction 23  
 Molecular chirality 30, 413, 414, 461, 462,  
   702  
 Molecular kinetic energy 27  
 Molecular rotation 24, 27, **39–46**  
 Molecular polarizability 22, 25, 49  
 Monoclinic (crystal system) 98, 99, 148  
 MOSFET 436, 458  
 MTN (Mixedmode Twisted Nematic)  
   284  
 Mueller matrix 546–562  
   table 554–555  
 Multidomain 29, 291, 419, 312, 331, 571,  
   576, 589, 647  
 Multiplexed Displays 426  
 Multiplexing  
   law of 384, 428  
 MVA-LCD 312, 589, 647  
 Mylar  
   index of refraction 104  
 N10 (Merck)  
   index of refraction 103  
 NaCl  
   index of refraction 101  
 NaNO<sub>2</sub>  
   index of refraction 101  
 NaNO<sub>3</sub>  
   index of refraction 101  
 Natural twist rate 370, 702, 705  
 NB-TN-LCD 211, 217, 223, 348, 349, 351,  
   356, 357, 359–365  
 Negative biaxial 160, 161  
 Negative birefringence 8, 25, 100, 101,  
   261, 514, 516, 570, 571, 605, 607, 615,  
   616, 659, 668, 669  
 Negative c-plate  
   compensator 589, 605, 606, 614–618,  
   620–625, 634–638, 641, 648, 656, 659,  
   662, 666  
   split 616–618, 620–622  
 Negative c-plate compensator  
   basic concept 605, 614, 659  
 Negative dielectric anisotropy 22, 24, 36,  
   46, 293, 294, 330, 579–581, 684,  
   687  
 Negative TN-LC  
   compensator 516, 614, 628–631, 643,  
   644, 646, 647  
 Negative uniaxial 99, 124, 137, 160, 606,  
   608, 668–670  
 Nematic LCD modes 388–398  
 Nematic phase 15–20  
 Nematic range  
   of liquid crystals 18, 23  
   tables 16, 23  
 Nematic-isotropic transition 15, 17,  
   20  
 Neutral biaxial 160–162, 171, 172, 251,  
   270  
 (NH<sub>4</sub>)H<sub>2</sub>PO<sub>4</sub>  
   index of refraction 101  
 N-I point 15, 17, 20  
 Normal dispersion 89

- Normal mode 84, 90, 92–97, 100, 104,  
108, 109, 129, 144–147, 151, 154–156,  
158–160, 166, 170, 173, 174, 195, 241,  
250, 251, 284, 286, 375, 377, 491, 493,  
496, 499, 507–509, 522, 590, 598, 603  
in CLC 461, 465–471, 477–480,  
482–484  
in general TN-LC 218–221, 241
- Normal surface **90**, 91, 95–100, 107, 115,  
117, 118, 120, 122, 123, 151–155, 164,  
185, 505, 506, 519, 527, 538
- Normally black (NB) 211, 238, 239, 291,  
304, 319, 332, 333, 353, 384, 392, 572,  
580
- Normally white (NW) 218, 238, 240,  
320, 353, 384, 396, 411, 511, 572, 664,  
666
- NW-TN-LCD 218, 334, 337, 338,  
344–349, 351–354, 357, 359–361,  
363–365, 371, 423, 513, 515, 567,  
572–574, 577, 578, 602, 606, 626, 646,  
647, 649, 653, 654, 656, 657
- OAP (see Optic axis plane)
- O mode  
in TN-LC 211, 212, 284, 320, 347, 348,  
360, 363, 364, 365, 425, 567, 568, 572,  
573, 577, 578, 653, 654, 656, 657
- O wave 107–110, 124, 127, 499, 670
- Oblate ellipsoid 615
- Oblate spheroid 663
- Octyloxycyanobiphenyl 23, 102, 103
- Odd-even effect 17
- OMI-LCD 215, 217
- O-plate 312, 507, 508, 568
- O-plate compensator 648, 651–655, 659,  
660  
phase retardation 506–507, 670, 671  
split 652, 654
- Optic axis **91**, 92, 97, 99, 100, 107, 125,  
139, 144, 146, 147, 151–154, 160, 164,  
172, 181, 233, 234, 246, 247, 252, 295,  
340, 524, 655, 669
- Optic axis plane (OAP) **100**, 151, 246,  
270
- Optical Activity **139**–149, 167, 462
- Optical compensator 570  
biaxial 571, 606, 611, 612, 623, 624,  
625, 642, **654–658**, 659, 663, 669, 670  
negative c-plate 589, 605, 606,  
614–618, 620–625, 634–638, 641, 648,  
656, 659, 662, 666  
o-plate 648, 651–655, 659, 660
- Optical dispersion 22, 55, 84, 87, 89, 101,  
143, 254, 260
- Optical mode interference (OMI) 215,  
217
- Optical rotatory power 139, 140–144,  
147, 162, 169, 368, 461, 462, 470,  
479–481  
table 140, 141
- Optical symmetry  
table 98, 99
- Optical theorem 723, 724, 725
- Order parameter 20, 21, 151, 398, 399,  
559, 668, 669  
typical values 21
- Ordinary polarization 3, 597
- Ordinary refractive index 24, 25, 118,  
126, 127, 321, 322, 400, 599, 672, 673
- Ordinary wave 109–111, 115, 118, 119,  
126, 127, 129, 158, 165, 226, 233, 320,  
360, 491, 493, 499, 500, 505, 507, 511,  
590, 593, 597–600, 602, 603, 625, 673
- Orientational order 18, 20, 21, 82, 107
- Orientational polarization 22, 24
- Orthogonal polarization states 3, 63, 68,  
79, 80, 133, 165, 557
- Orthogonal relationship 92, 105, 106,  
117, 170, 177, 471, 551
- Orthogonality 89, 93, 94, 104, 106, 124,  
471, 726
- Orthorhombic (crystal system) 98, 99,  
148
- Oseen-Frank theory 26, 47
- O-type polarizer 126, 127, 129–131, 252,  
285, 320, 321, 499, 500, 511–513, 515,  
597, 598, 609, 614, 665
- Out-of-plane retardance 161
- O-wave excitation 233, 491, 625
- Octyloxycyanobiphenyl 16
- $\pi$ -bond 16
- $\pi$  electron 16
- PAA 16
- Pancharatnam achromatic wave plate  
254–260, 716
- Pancharatnam phase 77, 78

- Pancharatnam theorem 77
- Parallel  
   Poincare sphere 69
- Parallel aligned cells 6, 46, 390, 589, 674  
   critical voltage 34
- Parallel alignment (PA) 20, 29, 107, 225, 316, 318, 399, 414, 659
- Parallel cylinders  
   form birefringence 664
- Parallel plates  
   form birefringence 664
- Partially Polarized Light 54, **64**, 67, 546, 547, 554, 556, 557
- Pascal-second 27
- Pauli matrix 551, 558
- P-Buff 320, 324
- PBDG  
   specific rotatory power 141
- PBLG  
   specific rotatory power 141
- PC (Polycarbonate)  
   index of refraction 104
- PCH-1132  
   index of refraction 103
- PCH-5  
   index of refraction 23, 103
- PD-LCD (Polymer dispersed LCD) 398–403
- PET  
   index of refraction 104
- PECVD 442, 443
- Pentylcyanobiphenyl 16, 23
- Pentyloxycyanobiphenyl. 16, 23
- Permanent dipole 22, 24
- Permeability 83, 87
- Permittivity 83
- Perturbation approach  
   biaxial media 158
- Phase 4 Licristal (EM-Merck), azoxy  
   index of refraction 102
- Phase retardation 2, 7, 9, 69–71, 74, 109–112, **125**, 162, 173, **176**, 177, 178, 185, 187, 191, 192, 194, 199–201, 203, 204, **208**, 211, 219, 223, **225**, **226**–233, 240–257, 259–276, 291, 293, **297**, 298, 300, 313, 317, 318, 343, 347, 376, 377, 381, 389–392, 394–398, 406, 415, 425, 447, 467, 478, 516, 530, 550, 568, 570, 572, 573, 576, 580, 584, 588, 591, 602–604, 606–608, 610–613, 615, 640, 641, 650, 651, 655, 659, 666, 670, 671, 716–719
- Phase Retardation at Oblique Incidence 125, 224–229
- Phase Retardation (achromatic) 254–264
- Phase Retardation (biaxial plate) 242–254
- Phase Retardation (in-plane) 161
- Phase Retardation (o-plate) 505–507, 568
- Phase Retardation (out-of-plane) 161
- Phase Retardation (wide field-of-view)) 269–76
- Phase retarder **70**–71, 550
- Phase transition temperature 17
- Phase velocity 7, 84, 86, 87, 89–92, 94, 108, 109, 142, 152, 163, 173, 174, 232, 467
- Phenyl 16
- Phenyl benzoate (COO), ester 17
- Phenyl ring 16
- Phenylcyclohexane 16, 23
- Pentylcyanobiphenyl 16, 23
- Pentylcyanoterphenyl 16, 23
- Pentyloxycyanobiphenyl 16, 23
- Phosphorus  
   Verdet constant 150
- Photoconductivity 434, 443
- Photoelectron 9,
- Photopic response  
   human eyes 306, 310, 339
- Pi cell ( $\pi$ -cell) 29, 51, 394, 396
- Pi electron ( $\pi$  electron) 16
- Pigment filter 8, 47
- Pitch 134, 137, 219, 368–370, 374, 382, 413, 414, 416, 461, 462, 464, 467–470, 477, 479–481, 484, 708
- Pixel 1, 4, 8, 9, 11, 12, 234, 290, 315, 329, 366, 408, 417, 418, 426, 427, 429, 431–435, 437–441, 443, 445, 448, 451, 452, 456, 457, 571, 576, 589, 647
- Pixel layout 433
- Planar state  
   in cholesteric LCD 416, 417
- Plane polarized light 57, 80
- Plane wave in homogeneous media 90–106

- Plasma-addressed LCD 419
- Plasma display device 1
- Plasma enhanced chemical vapor deposition (PECVD) 442
- Plexiglass  
index of refraction 104
- PMMA  
index of refraction 104
- p-Methoxybenzylidene-p'-n-butylaniline 16
- Poincaré sphere **67–78**, 133, 189, 247, 282, 550, 559, 597, 598, 601, 603, 604, 606, 607, 610–612, 614, 672, 712, 714–716
- Point group 98, 148
- Polarizability 22, 25, 49, 667, 668, 669, 724
- Polarizability tensor  
statistical average 667, 668, 669
- Polarization ellipse 59, 60, 62, 65, 68, 74–76, 77, 80, 143, 146, 147, 169, 191, 199, 266, 267  
ellipticity angle 62  
in TN-LC 212, 214, 215, 218–220, 283, 284, 422  
inclination angle 62
- Polarization ellipses  
in CLC 466, 468–471, 478, 479, 482, 484
- Polarization rotator 190–192, 281, 282
- Polarization state 2, 4, 6–8, 25, **54**, 55–78  
circular 57, 58  
complex number representation 61–62  
elliptical 57, 58, 60  
Jones vector representation 62–64  
linear 56  
of partially polarized light 64  
Poincaré sphere representation 67–76  
table 65–67
- Polarization state of normal modes  
in CLC 467–470  
in TN-LC 218–220
- Polarization transformation  
wave plates 71–76
- Polarizer 1, **2**, 3–8, 48, 49, 54, 64, 81, 82, **126**, 127–131, 133–135, 137, 150, 177, 188, 193, 194, 199–207, 211, 212, 215–218, 221–223, 229–238, 240, 241, 252, 263–269, 271, 278, 279, 283–287, 291–293, 298–301, 304, 306, 308, 313, 317–324, 331–338, 343, 344, 346–348, 363, 375–381, 384, 386–388, 390–392, 395, 396, 398, 403, 404, 406–411, 414, 431, 433, 445, **446**, 447–449, 571–574, 576–581, 583–585, 587–618, 620–628, 630, 632, 634–636, 638–642, 646, 650, 654, 658
- absorption axis 3, 4, 8, 126–129, 252, 253, 317, 320–322, 332, 348, 363, 524, 572–574, 590, 593, 598–600, 607, 609, 610, 612, 625, 634, 636, 638, 640, 642
- Birefringent Bragg reflector 138–139
- Circular 194–199
- CLC 447, 448
- E-type 126, 127, 130, 597, 598, 665, 673
- HN22 446
- HN38S 446
- HN42HE 446
- O-type 126, 127, 129–131, 252, 285, 320, 321, 499, 500, 511–513, 515, 597, 598, 609, 614, 665
- polarization state in 252–254, 598–601
- prism 3, 82, 165
- PVA-iodine 3, 126, 127, 162, 446, 597
- reflective 5, **133**, 134, 137–139
- transmission axis 8, 48, 49, 127, 135, 177, 197, 201, 203, 204, 211, 212, 214–217, 223, 229, 233–235, 237, 263–265, 271, 278, 283, 317–321, 324, 332–336, 338, 375, 380, 384, 390, 396, 414, 423, 424, 446, 500, 507, 511, 572, 573, 577, 578
- sheet 1, 3, 4, 6, 82, 126–128, 133, 177, 196, 221, 235, 237, 291, 299, 334, 346, 411, 424, 446, 501, 502, 597, 598
- wire grid 4, 5, **134**–138, 162, 421
- Polaroid 126, 446
- Poly gamma-benzyl-D-glutamate  
specific rotatory power 141
- Poly gamma-benzyl-L-glutamate  
specific rotatory power 141
- Polychromatic light 64
- Polycarbonate (PC)  
index of refraction 104
- Polyester 13, 104

- Polyester (PET)  
   index of refraction 104  
 Polyimide 6, 9, 104, 333, 334, 434, 438,  
   444, 445, 448, 449, 561, 571, 659  
 Polyimide (Kapton)  
   index of refraction 104  
 Polyiodine molecule 127  
 Polymer dispersed LCD 291, 398–403,  
   420  
 Poly-Si TFT 440, 441, 443, 444, 446  
 Polytetrafluoroethylene (PTFE)  
   index of refraction 12, 104  
 Polyvinyl alcohol (PVA) 70, 104, 126,  
   127, 446, 448, 659, 669  
   index of refraction 104  
 Polyvinylidene fluoride (PVDF)  
   index of refraction 104  
 Positive biaxial 160, 161  
 Positive birefringence 8, 25, 100, 101,  
   124, 210, 261, 516, 572, 590, 605, 607,  
   614, 615, 625, 648, 651, 659, 668  
 Positive uniaxial 99–101, 124, 160, 227,  
   605, 668  
 Power flow in anisotropic media 94, **100**,  
   **104**, 105, 106, 117, 168, 169, 471, 483,  
   540  
 Power orthogonal theorem 104  
 Power orthogonality 89, 106, 124  
   in CLC 471  
 Poynting vector 55, 88, 93, 100, 106, 114,  
   115, 124, 200, 520, 540, 722, 723,  
   725  
 Pretilt angle **29**, 30, 43, 50, 51, 295, 296,  
   303, 311, 314, 318, 340, 341, 348, 360,  
   395, 424, 511, 539, 567, 574, 581, 650,  
   687, 688, 706–708  
 Pretilt angle  
   in STN 370, 372, **373**, 374, 382,  
   383  
 Principal axis  
   dielectric 94, 98, 100, 106, 121, 124,  
   151, 160, 161, 170, 171, 219, 242, 243,  
   250, 270, 271, 281, 422, 468, 471, 478,  
   517, 533, 539, 541, 543–545, 565, 611,  
   658, 659, 663, 669, 670  
   ellipse or ellipsoid 155, 709, 710  
   of polarization ellipse 58, 59, 81, 146,  
   157, 169, 175, 215, 220, 283, 482, 484,  
   709, 710  
 Principal dielectric constant 84, 462, 518,  
   520, 563  
 Principal effective dielectric  
   susceptibility  
   composite media 710  
 Principal index of refraction 24, 25, 84,  
   97–98, 100, 144, 151, 158, 160, 161,  
   164, 171, 243, 251, 252, 270, 271, 390,  
   399, 416, 461, 612, 655, 662, 669, 670  
 Principal polarizability 667  
 Projection display 18, 235, 240, 291, 403,  
   407, **410**–412, 443, 447  
 Projection operator  
   method of 206–208  
   polarizer 278  
 Prolate 615, 652, 663  
 Propagation matrix  
    $4 \times 4$  529  
   extended Jones **494**, 502, 507, 509, 511,  
   520, 522  
 Proustite  
   index of refraction 101  
 P-Si TFT 440, 441, 443, 444, 446  
 PTFE 13, 104  
   index of refraction 104  
 Polyimide (Kapton)  
   index of refraction 104  
 PVA (Polyvinyl alcohol) 70, 104, 126,  
   127, 446, 448, 659, 669  
   index of refraction 104  
 PVDF  
   index of refraction 104  
 Quarter wave plate **71**, 72–78, 80, 110,  
   165, 192, 194, 196, 198, 199, 238, 240,  
   254–258, 265–269, 277, 284, 287, 409,  
   410, 554–556  
   effect on polarization state 72–78, 179,  
   180,  
   Jones matrix 178–179, 554, 555  
 Quartz 70, 71, 82, 84, 101, 112, 139, 140,  
   147, 261–263, 272, 274, 280, 441, 443,  
   462, 501  
   birefringence 262  
   index of refraction 101  
   specific rotatory power 140  
 Quasi-Circular Polarizer 194–199  
 Quasi-Circular Polarizer (Broadband)  
   264–269

- Quasimonochromatic wave 66  
 Quinine 126
- Radiance 10, 14  
 Random phase 3, 66, 200, 206, 495, 547, 559  
 Rayleigh's law (scattring) 730, 734  
 RC relaxation 437  
 RC time constant 438  
 Reciprocity (law of, principle of) 89, 179, **183**, 184, 185, 398, 407, 423, **544**, 545, 562, 576  
 Reciprocity theorem  
   anisotropic layered media 562, 565, 566, 569  
 Redness-greenness  
   CIE 1976 456  
 Reduced voltage 383, 385, 387–389  
 Reflection coefficient 114, 119–122, 124, 490–492, 496, 536, 537, 540, 541, 544, 562, 565, 566, 568  
 Reflectance  
   of CLC 475  
 Reflection and refraction 112–115, 124  
 Reflection and transmission 495, 496, 530–533, 536, 537, 540–544, 562, 563, 565, 568  
 Reflection property  
   of TN-LCD with a rear mirror  
 Reflective LCD 183, 185, 235, 236, 240, 241, 291, **404**, 405–408, 410, 417–419  
 Reflective polarizer 5, **133**, 134, 137–139  
 Refraction 3, 82, 104, 112–125, 140, 143, 152, 153, 164, 165, 226, 242, 401, 485–487, 495, 496, 498, 499, 508, 509, 521  
 Refractive index (see Index of refraction)  
 Resistivity 18, 438, 441  
 Restoring torques 26, 31, 33, 36, 45, 46, 294, 339, 680, 743  
 Retarder 69, **70**–74, 276, 546, 549, 550, 553, 557–559  
 Retardation plate 54, 173, 174, 176–178, 207, 281, 606  
 Retroreflection 179, 183–185  
 Ring systems 16
- Rings  
   conoscopy 232, 233  
 Rise time **39**–46  
   IPS cell 43  
   PA cell 43  
   TN cell 43  
   VA cell 43  
 Rochon prism 3  
 Rodrigues-Hamilton theorem 714  
 Rotation symmetry 218, 331, 376, 407, 413, 425, 540, 543, 576, 593, 626  
 Rotational motion  
   see Molecular rotation  
 Rotational viscosity 27, 39–42, 47  
 Rotational viscosity coefficient  
   table 23  
 Rotatory power 139, 140, 142–144, 147, 162, 169, 368  
   in CLC 461, 462, 470, 479–481  
   table 140, 141  
 RO-TN-601  
   index of refraction 102  
 Rubbing 6, 24, **27**, 28–31  
 Rubbing direction 6, 29, 333, 334, 339, 341, 367, 368, 372, 408, 424, 572–575  
 Rubbing materials 28  
 Rutile  
   index of refraction 101
- $\sigma$  electron 16  
 Sagnac interferometer  
   projection display 447  
 Sapphire  
   index of refraction 101  
 Saturated rings 16, 17  
 Saturation  
   CIE 1976 456  
 Saturation current  
   MOSFET 436  
 SbSI  
   index of refraction 101  
 Scan line 438, 439  
 Scattering cross section  
   Mie 400–403, 721–740  
 Selection ratio 384, 387, 428, 429, 458  
 Selenium 140  
   specific rotatory power 140  
 Self-alignment  
   p-Si TFT 444

- Sequence of phase changes 19–20  
 Shearing stress 27  
 Sheet polarizer 1, 3, 4, 6, 82, 126–128, 133, 177, 196, 221, 235, 237, 291, 299, 334, 346, 411, 424, 446, 501, 502, 597, 598  
 Schiff base 17, 102  
 Side chain 17, 28  
 $\sigma$ -bond 16  
 Sigma electron 16  
 Silane coupling agent 28  
 Silica (fused)  
   index of refraction 104  
 Silicone  
   index of refraction 104  
 Silve thiogallate 140  
 Silver gallium sulfide  
   specific rotatory power 140  
 Sine rule 714  
 SiN<sub>x</sub> 442  
 SiO<sub>2</sub> 101, 104, 443, 444, 462, 662  
   index of refraction 101, 104  
 Sixth-wave plate 589, 606–609, 616–618, 621, 625–627, 630, 631, 637, 639, 644, 646, 647, 665  
 Slow axis 70, 173, 174, 192  
 Slow twist 219, 220, 335  
 Small birefringence approximation  
   495–501, 502, 505, 507, 509, 516, 522  
 Smart window 403  
 Smectic (phase) 17–21  
 Smectic A  
   optical symmetry 99  
 Smectic B  
   optical symmetry 99  
 Smectic C 412, 413  
   optical symmetry 99  
 Smectic C\* 413  
 Smectic D  
   optical symmetry 99  
 Smectic E  
   optical symmetry 99  
 Smectic F  
   optical symmetry 99  
 Smectic G  
   optical symmetry 99  
 Smectic H  
   optical symmetry 99  
 Smectic I  
   optical symmetry 99  
 Smectic J  
   optical symmetry 99  
 Smectic K  
   optical symmetry 99  
 Snell's law 113  
 SnO<sub>2</sub>  
   index of refraction 101  
 SnO<sub>2</sub> (tin oxide) 5  
 Sodamine 441  
 Sodium benzoate 15  
 Sodium chlorate 140  
 Sodium chloride  
   index of refraction 101  
   Verdet constant 150  
 Sodium nitrate  
   index of refraction 101  
 Sodium nitrite  
   index of refraction 101  
 Solid crystals  
   optical symmetry, table 98  
 Specific rotatory power 140, 142, 143, 169  
 Spectral tristimulus 452, 455  
 Speed of light in vacuum 87  
 Spherical Bessel function 726, 727, 728  
 Spherical trigonometry 712  
 Splay 26, 29, 34, 40, 41, 47, 676, 679  
 Splay cell 29, 51  
 Splay elastic constant 34, 40, 41, 47, 679  
 Spontaneous twist 18  
 SSF-LCD 414  
 Stability under UV illumination 18  
 Standard colorimetric observers  
   CIE 1931 452  
   CIE 1964 452  
 Steric factors 28  
 STN (supertwist nematic)  
   see supertwist nematic  
 STN-LCD 215, 217, 290, 365, 374, 375, 377, 381, 384, 385, 388, 389, 419, 423, 424  
   blue mode 380  
   normally black mode I 379  
   normally black mode II 380  
   normally white mode I 378  
   normally white mode II 378

- polarizer azimuth angles 375, 386
- yellow mode 378
- Stokes parameter 65–67, 69, 81, 133, 546, 547, 549–551, 556, 559, 601
- Stopband
  - in CLC 467, 475–477, 482
- Storage capacitor 433, 434, 438, 440, 448
- Stretched film 3, 126, 127, 559, 659, 669
- Structure chirality 462
- Strychnine sulfate 140
- Subpixel 8, 314, 315, 408, 417, 451, 452, 456
- Sugar 140
- Sulfur
  - index of refraction 161
- Supertwisted nematic (STN) 290, 291, 364–388
  - electrodistortion curves 373, 383, 387
  - electro-optical distortion 702
  - field-OFF state 374–381
  - field-ON state 381–384
  - steepness of electrodistortion curves 367
- Surface stabilized ferroelectric LCD 414
- Surface topography 28
  
- T15 16
- TAC
  - index of refraction 104
- Teflon
  - index of refraction 104
- te mode 219
  - excitation 284
- Tellurium 140
  - specific rotatory power 140
- Tenite
  - index of refraction 104
- TeO<sub>2</sub>
  - specific rotatory power 140
- Terminal group 15, 16, 18, 25
- Terminal group X 17
- Terminal group Y 17
- Terphenyl 17
- Tetragonal (crystal system) 98, 148
- TFT 2, 9, 11, 12, 18, 290, 291, 417, 431–446, 449, 459, 571, 596
  - aperture ratio 438, 440, 448, 449
  - array circuit 431, 432, 446
  - array fabrication 440
  - a-Si 433, 434, 437, 440, 441, 443, 444
  - bottom gate structure 440, 442, 443
  - CdSe 440, 441, 445, 446
  - coplanar structure 440–441, 443
  - c-Si 440
  - driving voltage waveforms 439
  - fabrication process 440–446
  - inverted staggered structure 440–441, 445
  - poly-Si 440, 441, 443, 444, 446
  - principle of operation 431
  - top gate structure 440, 443
  - optical throughput 446
- Thick diffuser 735
- Thin film transistor (TFT)
  - see TFT
- Threshold voltage 17, 36–39, 43, 429, 436, 437, 459
  - IPS cell 39, 319, 325
  - Nematic cell 340, 390, 593, 627
  - PA cell 34,
  - STN cell 374, 382, 707, 708
  - TN cell 39, 340, 342–344, 574, 575, 699, 701
  - VA cell 37, 292, 295, 298, 582
- Tilt angle (of director) 29–32, 35–37, 40, 44–46, 50, 51, 53, 294–297, 318, 339–343, 351, 371, 372, 374–376, 381–383, 387, 391–393, 395, 415, 574–576, 579, 581–583, 587, 640, 642, 649–651, 660, 675–677, 680, 682–688, 694, 697, 698, 700, 701, 703, 705–708
- Tilt angle (of director)
  - table 296, 343
- Tilt mode
  - electro-optical distortion 680
- Time reversal symmetry 183, 537, 539–542, 568, 569
- Tin oxide (SnO<sub>2</sub>) 5, 101
- TiO<sub>2</sub>
  - index of refraction 101, 662
- TN displays
  - see Twisted nematic displays
- to mode 219
  - excitation 284
- Tolane 17, 25
- Top gate structure
  - TFT 440, 443

- Topas  
 index of refraction 104
- Topaz  
 index of refraction 101, 161
- Torque (see restoring torque)
- Tourmaline 3, 126  
 index of refraction 101
- Transflective LCD 291, 407–410, 419
- Transmission axis  
 Polarizer 8, 48, 49, 127, 135, 177, 197, 201, 203, 204, 211, 212, 214–217, 223, 229, 233–235, 237, 263–265, 271, 278, 283, 317–321, 324, 332–336, 338, 375, 380, 384, 390, 396, 414, 423, 424, 446, 500, 507, 511, 572, 573, 577, 578
- Transmission coefficient 114, 119, 120, 122, 490, 492, 493, 495, 496, 497, 499, 502, 508, 509, 511, 521, 531, 533, 536, 537, 540, 541, 544, 562, 565, 568
- Transmission formula  
 general TN-LCD 215–218
- Transmission spectrum  
 STN-LCD 379
- Transmitted luminance 305–312
- Transparent electrode 1, 2, 4, 290, 291, 333, 390, 394, 395, 446, 449, 572, 595
- Transverse polarizability 22, 49, 667
- Transverse wave 54, 55, 88
- Triacetyl cellulose (TAC)  
 index of refraction 104
- Triclinic (crystal system) 98, 148
- Trigonal (crystal system) 98, 148
- Triple bonds 25
- Tristimulus value 451, 452, 453, 455, 456, 459, 460  
 table 453–454
- Tunable wave plate 192–194
- Turpentine 140
- Turquoise  
 index of refraction 161
- Twist 18, 26, 30, 42, 213, 220, 240, 318, 332, 335, 339, 348, 363, 370, 371, 374, 375, 381, 387, 389, 406, 416, 461, 572, 573, 627, 629
- Twist angle (of director) 30, 42, 49, 290, 689–693  
 CLC 462, 463  
 IPS 41, 317–319, 324–327, 592, 593
- STN 367–369, 372, 373, 375, 377, 382, 383, 387, 702, 703, 705, 706, 708  
 table 327, 343, 628, 630
- TN 30, 39, 208, 209, 211, 212, 215, 217, 219, 220, 223, 235–239, 331, 334–336, 339–342, 348, 363, 407, 511, 512, 514, 574, 575, 694, 696, 700, 701
- Twist elastic constant 26, 39, 42, 325, 414
- Twist mode  
 electro-optical distortion 689
- Twist rate 211, 220, 221, 283, 370, 371, 375, 377, 382, 387, 424, 702, 703, 704, 706, 707
- Twisted extraordinary mode (te mode) 219, 284
- Twisted nematic (TN) cell 7, 30, 99, 173, 208–224, 367  
 adiabatic following 208, 210  
 electro-optical distortion 694  
 mid-layer tilt angle vs voltage 342  
 normal modes of propagation 218, 220  
 tilt and twist angle of director 341, 343  
 threshold voltage 39, 340, 701  
 transmission properties 215  
 waveguiding 208, 210
- Twisted nematic display 210, 290, 291, 331–365  
 contrast at normal incidence 344, 347  
 E mode operation 363, 371  
 field-induced director reorientation 339  
 normally black (NB) mode 336, 342  
 normally white (NW) mode 337, 344, 359, 361, 363  
 O mode operation 348  
 principle of operation 332, 334  
 transmission at field-off state 335  
 transmission at field-on state 339  
 transmission at normal incidence 342  
 transmission of NB mode 337, 344, 349  
 transmission of NW mode 338, 345, 349  
 viewing angle characteristics 347–365  
 with compensator 626–631, 643–647, 648–659
- Twisted ordinary mode (to mode) 219, 284

- Two-fold rotation symmetry  
in ferroelectric LCD 413  
of BA-LCD 425  
of reflective LCD 407
- Uniaxial alignment 3, 127, 597
- Uniaxial birefringence 3, 138, 225, 291,  
384, 389, 509, 520, 571, 579, 590, 615,  
651, 660, 669, 670
- Uniaxial media 97, 99–101, 107, 115, 117,  
127, 129, 137, 144, 151, 157–160, 163,  
173, 178, 199, 219, 227–229, 231, 245,  
246, 254, 260, 261, 269, 271–273, 275,  
280, 282, 297, 321, 342, 422, 486–488,  
493, 496–498, 505, 507, 509, 510, 514,  
516, 523, 579, 589, 597, 598, 602, 605,  
606, 608, 614, 615, 660  
light propagation in 107–112  
propagation along the c-axis 111  
propagation in the xz-plane 110  
propagation perpendicular to the  
c-axis, 109  
refraction and reflection 117–125
- Uniaxial symmetry 21, 24, 98, 252, 663,  
668, 669
- Unidirectional alignment 151
- Unidirectional compression 127
- Unidirectional parallelism 126
- Unidirectional tilt 28
- Unpolarized Light 2–5, 8, 48, 49, 54,  
64–67, 81, 115, 119, 124, 128, 129,  
133, 154, 166, 169, 195–198, 200–202,  
205, 216, 236, 254, 264, 268, 271, 272,  
298, 318, 322, 333, 335, 336, 338, 384,  
400, 409, 446–448, 495, 500, 503, 511,  
514, 546, 554, 556, 557, 559, 599, 608,  
613, 734
- Unsaturated rings 16
- Vacuum fluorescence 1
- VA-LCD (see Vertically aligned  
LCD)
- van de Hulst approximation 401, 420,  
728
- van der Waals interactions 28
- Verdet constant 149, 150
- Vertical alignment 28, 291
- Vertical switching  
N-LCD
- Vertically aligned (VA) cell 7, 29, 36–39,  
41, 43, 44, 52, 290–295, 297–301, 311,  
312, 388, 416, 420, 570, 684, 687  
critical voltage 37, 686
- Vertically aligned LCD 291–316, 320,  
331, 408, 419, 570–572, 579–589, 591,  
602, 605, 614, 615–626, 631, 632–641,  
642, 647, 649, 684
- Viscosity 16–18, 23, 27, 39, 41, 42, 45  
definition 27
- Viscosity (rotational)  
table 23
- Voltage shift 438, 439
- Wash out 407
- Water  
Verdet constant 150
- Wave plate  
see also retarder 29, 69–77, 80–82, 110,  
162, 165, 173, 177–181, 186–188,  
190–194, 196–200, 203, 208, 238, 240,  
241, 246, 252, 264–272, 275, 277, 278,  
280–282, 284, 285, 287, 289, 291, 293,  
298, 327, 331, 377, 391, 394, 409, 410,  
448, 485, 494, 516, 554–556, 562, 589,  
606–614, 616–618, 620, 621, 623,  
625–627, 630, 631, 637–639, 644, 646,  
647, 652, 665  
achromatic 254–264, 289  
tunable 192–194  
wide field-of-view 269–276
- Waveguide 12–14, 731, 734, 735
- Waveguiding  
in TN-LC 208, 210, 211, 212, 214, 478,  
484
- White  
daylight 460  
equienergy 460
- White light 311, 312, 460
- Wide field-of-view element 269–276
- Wire grid polarizer 4, 5, **134**, 135, 162,  
421
- Wollaston prism 3
- X-Buffer 320, 324
- X-cube 412
- YAlO<sub>3</sub>  
index of refraction 101

- YVO<sub>4</sub>
  - index of refraction 101
- Yellow mode
  - STN-LCD 378
- Yellowness-blueness
  - CIE 1976 456
  
- Zeeman effect 150
- Zeonor
  - index of refraction 104
- Zinc oxide 5
  
- Zircon
  - index of refraction 101
- ZLI-1646 23, 35, 36, 43–45, 49, 50, 52,  
103, 164, 223, 277, 325, 329, 340, 501
  - index of refraction 23, 103
- ZLI-4792 23, 103
  - index of refraction 23, 103
- ZnO 5
- ZnS
  - index of refraction 101
- ZrSiO<sub>4</sub>
  - index of refraction 101