

Index

- acousto-optic effect 243–44
air bandedge 35, 266
air gap 188, 197, 224, 240–41
air holes 16–17, 52–53, 55, 64,
 189, 192, 216–18, 241–43,
 245, 266–68, 270–72,
 298–99, 333–34, 336–37,
 341–42
air pores 189, 268
air voids 127–29
all-dielectric photonic crystal 31,
 34, 47, 49
all-optical logic flip-flop 328–29
all-optical switching effect 151,
 157, 159, 170–72, 174, 176,
 195, 199, 201
applications
 all-optical switching 212
 integration 230, 346
 optical 81, 131
 terahertz frequency 240
average transmittance 35–36,
 235, 251–52
- BaF₂ crystal 41
biochemical sensor 7, 316,
 336–40, 344–46
- Cantor multilayer 39
capillary condensation 190, 210
ceramic materials 101
- CFC *see* constant frequency contour
cholesteric liquid crystals (CLC)
 288–93, 301–3, 305–7, 315,
 317
cladding layer 282, 298
CLC *see* Cholesteric liquid crystals
colloidal crystals 11, 117–18, 121,
 128, 142–43, 296–97, 316
colloidal microspheres 124–25
colloidal nanospheres 117–18,
 120–21, 123–26, 128
colloidal photonic crystal laser
 268–69
colloidal suspension 122, 124–26,
 128, 294
complete photonic bandgap 2, 5,
 18, 60, 62–66, 74, 105, 108–9,
 127, 140
composite material structures 178
constant frequency contour (CFC)
 41, 47–51
contours, equal-frequency 325
coupling
 contra-directional 222
 waveguide-microcavity 156–58
crystallographic orientation 121
- DBR *see* distributed Bragg
 reflection
defect layer 78, 154–55, 165, 191,
 220, 229–30, 278, 304
 nonlinear 154–55
defect mode lasing 315, 317

- defect mode shift mechanism 148, 151–52
defect mode shift method 150–52
defect mode shifts 163, 165, 173, 193, 219, 304
defect modes 4, 23, 149–52, 154–55, 160–61, 172–73, 203–4, 216–20, 225–26, 229–30, 245–48, 263–64, 276–78, 291–92, 304
defect rods 160
defects
 acceptor-type 218–19
 twist 291–92, 315
destructive interference 15, 20, 23, 25, 223, 227, 230–31, 325–27
dichromate gelatin emulsions 108, 140, 308–9
dielectric bandedge 35, 199, 266
dielectric cylinder 49, 69
dielectric function 14, 16, 18, 20, 31, 43, 60, 233
dielectric layers 14–15, 31, 33–35, 38–39, 41–42, 75, 165, 180–81, 185
dielectric materials 13–14, 16–17, 19–20, 27, 31–32, 34, 38, 42, 52, 65, 93, 99, 101, 105, 149
 dispersion properties of 15, 17
dielectric periodicity 14–16, 18
dielectric rods 16–17, 94, 133, 135, 323, 326–27
distributed Bragg reflection (DBR) 266, 280
distributed feedback mechanism 284–87
donor-type defect 219, 246
- effective plasma frequency theory 33
- electric field distribution 62, 153, 155–56, 160, 179–80, 182, 186, 197, 218, 248, 281–82, 334, 336, 338
electrochemical etching 78, 80, 88–89
electron-beam lithography method 84–85, 91, 93, 103
environmental refractive index 337, 339
equifrequency curve variation method 162–63
equifrequency surface curves 162–63
- Fano resonance 193–94, 211
femtosecond lasers 83, 101–2, 131, 136, 138
femtosecond pump 173–74, 176, 195, 201, 246
FIB *see* focused ion beam
Fibonacci multilayer 39
fluid sensor 7, 333–36
focused ion beam (FIB) 78, 84, 116, 133–34, 166, 170–71, 195, 244, 261
- gain medium 6, 264–65, 267, 270–71, 273, 276, 280–84, 286–88, 293, 296, 298–301, 334
gas sensor 7, 341–43, 346
glass substrates 37, 118–20, 186
gravity sedimentation method 118, 123, 126–27
Green function method 25, 44, 46
guided modes 237–38, 276, 282, 334, 338
guided resonance effect 241, 339–40

- heterostructure, metal-dielectric 181
 hexagonal lattice 85, 103, 160
 high-quality photonic crystal samples 3–5, 150
 fabrication of 3, 5
 holographic lithography method 84, 89–90, 98, 103–5, 107–10, 112, 114
 phase-controlled 83
 traditional 116–17
 holographic polymer 105, 139

 icosahedral quasicrystals 107, 139–40
 InGaAsP quantum well material 267, 270–71, 273, 281–83, 334
 integrated photonic devices 1, 3–4, 6–7, 14, 18, 47, 49, 77, 147, 177, 195, 215, 244, 263
 realization of 3–4, 77
 ion-beam etching 85–86, 91

 laser beams, femtosecond 93–94, 96, 98, 100–1
 laser emission 264–66, 268, 271–72, 276–77, 279, 283–85, 289–92, 296, 299, 301–2, 304, 306–7, 310, 313, 315
 laser oscillation 265–67, 270, 275–76, 279, 282, 284, 286, 294, 300, 302
 laser oscillation mode 266
 laser radiations 293–94, 296
 lattice constant 19, 24–25, 37, 82, 85–87, 101, 112, 169–71, 192–93, 266–68, 270–73, 275–76, 281–83, 285–87, 334–38
 lattice defect 3–4, 118, 123, 152, 161, 197
 layer spacing 101–2
 layered composite structures 179
 line defect 117, 152, 171–72, 195, 197, 216, 232, 245–47, 282, 326, 333
 line defect waveguide 270, 281–82, 333–34
 line defect waveguide microcavity 281, 283
 liquid crystal
 ferroelectric 301
 infiltration of 57
 negative dielectric anisotropy 305
 polymer-dispersed 303
 polymeric cholesteric 293, 315
 refractive index of 57, 301, 303
 liquid crystal defect layer 304–5, 317
 liquid crystal material 165, 186, 240
 dispersed 105
 liquid crystal molecules 186–87, 279, 291, 300
 liquid crystal photonic crystal 186, 301, 303
 logic gate, all-optical 320–21, 323, 325, 327

 Maxwell equations 20, 25, 35, 61, 75
 MBE *see* molecular beam epitaxy
 metal-dielectric multilayer
 structure 180–81, 185–86, 210
 metallic lugs 240–41
 metaldielectric gratings 40, 68

- microcavity mode shift 191, 336–37, 341
- microcavity photon lifetime 191–92
- microcavity resonant mode 197–98, 270
- microexplosion 99, 101, 103
- microfabrication 136
- molecular beam epitaxy (MBE) 5, 234

- nanoimprint lithography 87–88, 134
- nanopolymer 279–80
- nanospheres 120, 125–26, 189
- narrow-band photonic crystal filter 216
- nonlinear frequency conversion 320–21
- nonlinear photonic crystal microcavity 152, 158
- nonlinearity enhancement 179, 181–82

- one-dimensional metalldielectric photonic crystals, applications of 40
- optical nonlinearity 155, 167, 170, 181–82, 189, 195, 205–7, 212
- optical parameter amplifier 170, 172
- optical susceptibility, third-order nonlinear 180, 183–84
- optical waveguide 65, 157–58, 216–18, 220–21, 223–26, 236, 323, 338
- organic conjugated polymer materials 167, 177, 194
- organic photonic crystal laser 286–87

- phase mask 104, 111–16, 141
- multidimensional 114–15
- two-dimensional 112, 114
- photoinitiators 90, 105, 113–14, 303
- photon confinement 65, 246, 248, 275–76
- photon confinement effect 4, 246, 248, 272, 276, 282
- photon localization effect, strong 152–53, 155, 160
- photonic band structures 2–4, 7, 23, 33, 43, 46–47, 49–50, 61–63, 72, 162–63, 266, 302
- photonic bandedge laser 265–66, 268, 317
- photonic bandedge mode 155, 265
- photonic bandedges 6, 23, 38, 42, 50, 149–50, 263–65, 267–68, 270, 281, 298, 301–2
- photonic bandgap 2–4, 13–21, 23–25, 27–32, 36–38, 56–57, 148–52, 169–71, 173–76, 189–93, 245–50, 263–67, 289–91, 298–303, 306–7
- complete three-dimensional 63–66
- complete two-dimensional 64–66
- fundamental 24, 27, 64, 103, 266
- photonic bandgap microcavity 158, 195, 197, 199, 261, 270–71, 321–22
- photonic bandgap properties 27, 34, 333
- photonic bandgap shift mechanism 148–50, 152
- photonic bandgap shifts 29–30, 37, 148–49, 161–63, 169, 213, 296, 306–7
- photonic crystal, fundamental principles of 3
- photonic crystal bandgap shift 150–51

- photonic crystal fiber 244
 photonic crystal filter 3, 6–7,
 215–17, 219–31, 233, 235,
 237, 239–43, 245–47,
 249–52, 262
 configuration of 215, 217, 219,
 221, 223, 225, 227, 229, 231,
 233, 235, 237
 five-channel 226
 multichannel 224–25, 229, 232
 silicon 217, 219
 single-channel 216–17, 224, 241
 surface-emitting 217–18
 tunable metallic 240, 260
 photonic crystal heterostructure
 63, 163, 207, 223, 228, 232,
 275, 312
 photonic crystal heterostructure
 microcavity 275
 photonic crystal laser 3, 6, 263–82,
 284–92, 294, 296, 298, 300,
 302, 304–6, 308–10, 312,
 314, 316
 tunable liquid crystal 301
 photonic crystal laser devices 287,
 289
 photonic crystal line defect
 waveguide 282–83
 photonic crystal line defect
 waveguide microcavity
 laser 283
 photonic crystal logic devices 6,
 319–20, 322, 324, 326, 328,
 330
 photonic crystal microcavities
 high quality factor 191, 341
 identical 6, 338
 one-dimensional 154, 191
 quasiperiodic 276, 312
 photonic crystal microcavity 4,
 6, 151–52, 154–56, 187,
 190–94, 220–21, 223, 239,
 242, 280–81, 329, 333–34,
 336–37, 341–42
 photonic crystal microcavity laser
 264, 270–71, 278, 312, 317,
 335
 photonic crystal microcavity modes
 6, 158, 185
 photonic crystal optical switching
 163, 165, 167, 169, 171, 173,
 175, 177, 179, 181, 183, 185,
 187, 189, 191
 photonic crystal sensors 6–7,
 333–34, 336, 338, 340, 342,
 344, 346
 photonic crystal slab superlens
 48–49, 52–55
 photonic crystal slabs, single 239,
 241, 258
 photonic crystal waveguides 10,
 156, 158–59, 173–74,
 187–88, 193, 209–10, 218,
 226, 237, 264, 313, 324–25,
 334–35, 341–42
 parallel placed 220, 222
 silicon 187–88, 192
 photonic crystals
 application of 1, 4–6, 18
 chirped 82–83
 circular spiral 94–95
 CLC 290–91
 colloidal 90, 121, 124–27, 164,
 268–69, 296
 composite 195, 199
 configuration of 14–15, 17
 defect-free 10, 117, 265
 dielectric 56–57
 fabrication of 2, 4–5, 9, 131,
 133–34, 144
 fabrication technique of 77–78,
 80, 82, 84, 86, 88, 90, 92, 94,
 96, 98, 100, 102, 104, 106
 fundamental properties of
 13–14, 16, 18, 20, 22, 24, 26,
 28, 30, 32, 34, 36, 38, 40, 42
 high-quality colloidal 124

- holographic fabrication of three-dimensional 114–15
- honeycomb 90, 133–34
- linear chirped 82
- low-power 167, 185, 194, 213
- metal 3, 60, 232
- metallic 56–59, 71, 165, 232, 240, 260
- metallodielectric 31, 33–39, 41–43, 67, 71, 180, 235, 287–88
- microstrip 232, 256
- nanocomposite 200
- nonlinear 8, 69, 147, 189, 202–3, 205, 320, 330
- one-dimensional 5, 14–16, 23, 25–29, 31, 41, 77–81, 83, 129–30, 165–66, 174–75, 191, 216–17, 229–30, 303–4
- one-dimensional all-dielectric 27, 31–32, 36
- one-dimensional metallic-dielectric 67–68
- one-dimensional metallodielectric 31–34, 37–43, 235
- one-dimensional $\text{SiO}_2/\text{TiO}_2$ 78
- perturbed one-dimensional 228
- polystyrene 120, 170, 172
- quasiperiodic 232–33, 265, 277
- semiconductor 161, 189, 271, 273, 282
- slanted pore 63–64, 98–99, 137
- square spiral 63, 73
- three-dimensional 2, 5, 9–10, 18–19, 60–65, 72, 90–93, 95, 97–121, 123, 125, 127–29, 135–36, 139–41, 293–95
- three-dimensional colloidal 5, 118, 120, 122, 125, 296
- three-dimensional layer-by-layer 11, 61–62
- three-dimensional polymer 92, 96, 131, 136
- three-dimensional silicon 91–92, 96, 168
- three-dimensional spiral 109
- triangular lattice 270–71, 283, 337
- truncated 207, 338–39
- tunable metallic 57, 71
- two-dimensional 16–18, 43–45, 47, 49, 51, 64, 66, 70–71, 84–87, 89, 160–61, 173, 261, 284–86, 330
- two-dimensional all-dielectric 49–50
- two-dimensional metallic 56–58
- two-dimensional metallodielectric 287
- two-dimensional organic 5, 204, 261
- two-dimensional PMMA 85
- two-dimensional polystyrene 170–72
- two-dimensional quasiperiodic 276
- two-dimensional SiO_2 285
- two-dimensional tungsten 59–60
- unchirped 82
- unique properties of 3–4
- photonic materials 13, 177
- artificial 13–14, 56
- photonic quasicrystals 5, 64, 107–8, 134, 268
- three-dimensional 107–8
- two-dimensional 74, 89, 132, 134, 268
- photonic technology, integrated 1, 13, 149
- photoresist 83, 93, 96–97, 103, 110, 112–14, 118
- plane-wave expansion method 4, 44–45
- PLD *see* pulsed laser deposition
- PMMA *see* polymethylmethacrylate

- point defect 126, 152, 157–58, 216–18, 223, 226, 243, 255, 274–75, 279, 281–82, 313
- polymer materials 102, 244
organic 5, 101
- Polymerization, multiple-photon 93, 97–98
- polymethylmethacrylate (PMMA) 80, 85, 92, 278
- polystyrene 118, 128, 145, 170, 195, 199, 205, 244, 247, 250
- polystyrene nanospheres 118, 121–23, 126, 128, 176
- polystyrene opal 128, 145, 170–71, 176, 204, 297
- polystyrene waveguide 173, 197
- porous silicon layers 83
- porous silicon photonic crystal 340
- porous silicon superlattice 190
- pulsed laser deposition (PLD) 5
- pump laser 161, 169–70, 201, 271, 289
- quantum wells 192–93
- reflectance 23–24, 26
- refractive index units (RIU) 338
- resonant frequency 3, 14, 32, 149, 151–54, 156–59, 161, 194, 216, 218–21, 224–26, 232, 239, 241–43, 334
degenerate 218–19
- resonant tunneling effect 32, 222, 226–28, 230, 237
- RIU *see* refractive index units
- self-collimation effect 325–26
- semiconductor crystal 22
- semiconductor materials 1, 13–14, 161, 167, 267
- semiconductor quantum dots 8, 63, 65–66, 183–84, 194, 264
- silicon 52, 59, 81, 84, 96, 127–31, 134, 137, 142, 167–70, 175, 192–93, 204, 211, 256
amorphous 168, 174–76
- silicon nanowire 342
- silicon nanowire arrays 342
- silicon output waveguide 283
- silicon substrates 82, 85
- silicon waveguide 203, 217, 283
- silver 31–32, 34, 42, 179
- SiO_2 27–29, 78, 85, 92, 96, 127, 165, 174, 180, 184, 220, 235, 243, 286, 304–5
- SiO_2 opal 168, 175, 280–81, 294–95
- SnO_2 porous material 343–44
- sol-gel method 5, 78–79, 131
- SPP *see* surface plasmon polaritons
- SPR *see* surface plasmon resonance
- superlens 41, 53–54
all-dielectric photonic crystal slab 51–52, 55, 71
- surface-emitting lasers 280, 309, 312, 314
vertical-cavity 279, 307, 312
- surface plasmon polaritons (SPP) 3, 31, 40
- surface plasmon resonance (SPR) 183
- surface plasmons 59, 67–68, 116–17, 142
- surface wave microcavity 224, 339
- switching efficiency 166–67, 175, 188, 192, 194, 201
- three-dimensional photonic crystals, fabrication of 2,

- 100, 102–3, 115–16, 118, 128, 136, 140
- TiO_2 28–29, 78, 127, 278, 305, 340
- TMM *see* transfer matrix method
- TPA *see* two-photon absorption
- transfer matrix method (TMM) 4, 25–30, 34–36
- transmittance contrast 29–30, 165, 167, 170, 248, 251
- transmittance spectra 30, 36–37, 101
- tunability, all-optical 246, 249, 251, 260
- tunable negative refraction 49, 51, 70
- tunable photonic crystal filter 215–16, 218, 220, 222, 224, 226, 228, 230, 232, 234, 236, 238–52, 254, 256, 258
- tunable photonic crystal laser 293–95, 297, 299, 301, 303, 305, 317
- two-dimensional InAsP photonic crystal line defect waveguide laser 282
- two-dimensional InP photonic crystal 87–88, 281
- two-dimensional photonic crystal filter 244–47, 250
- two-dimensional photonic crystal heterostructure 230
- two-dimensional photonic crystal microcavity 192, 195
- two-dimensional photonic crystal slabs 18, 70, 225, 227, 238–39, 253, 257
- two-dimensional photonic crystal structure 47, 284
- two-photon absorption (TPA) 42, 93–94, 96
- ultraviolet light 306–7
- uniaxial crystals 65
- VCSEL *see* vertical cavity surface emitting laser
- vertical cavity surface emitting laser (VCSEL) 266
- vertical deposition method 3, 122–23, 126, 170, 176, 280
- VO_2 168
- voxels 98–99, 101
- waveguide coupling mechanism 158
- waveguide coupling method 158, 160
- waveguide-microcavity coupling method 155
- waveguides composite 197
coupled-microcavity 236–37
slot 338
- wavelength division multiplex (WDM) 6
- WDM *see* wavelength division multiplex
- YAG laser 42, 170, 172, 269
- ZEP-520 layer 85
- ZnS/MgF_2 photonic crystal 37–38