а

aberration correction 109-110, 204 absorption spectrometer Lambert's law 85-86 optical spectrum, application of 87-89 spectrometer device 86-87 Ag, core-shell nanostructures 149–152 Ag nanocubes 56, 57, 106, 131, 274, 289, 293-295, 394, 413, 414 Ag nanoplates 88, 89, 131, 226, 228, 230-235, 238, 242-249, 261, 294, 322 Ag nanostructures directed hollow nanostructures 273-274 Ag nanowires growth mechanism 190–192 overgrowth 192–194 synthesis approaches 188–190 alloy Au/Ag nanorods co-reduction method 157-159 thermal annealing method 158, 160-164 4-aminothiopheno (ATP) 62, 63, 417, 426-429 anisotropicity (α) 227 anisotropy characteristic 138 anti-Stokes Raman scattering 90, 91 ascorbic acid (AA) 137, 141, 142, 144, 145, 149, 158, 194, 196, 201, 202, 229, 238, 250, 282 atomic deposition mechanisms facet selectivity 288-289 pH system 289-293 atomic force microscope (AFM) analysis 74-76, 93, 94, 334 AuAg core-shell nanostructures 152-156 AuAg NRs 164-168, 428 Au and Ag nanoplates 228 different size 249-251 growth mechanisms 235-248

hydrothermal and solvo-thermal approaches 232-233 optical properties 248-249 photochemical synthesis 233-235 polyol process 231-232 seed-mediated growth 229-231 Au nanobipyramid-embedded nanocages 284-286 nanoframes 282-283 open nanostructures 280-281 Pd nanorod arrays 286-288 Au nanobipyramids precise growth 137 - 139Au nanocylinders 65, 66 Au nanoframes 274, 282, 286-288, 295, 297-299, 384, 426, 427 Au nanoparticles (NPs) 26, 27, 30, 31, 41, 44, 62, 65, 95, 134, 139, 171, 173-175, 199, 229, 240, 255, 281, 296, 297, 311, 317, 318, 320, 324, 334, 345, 346, 351, 352, 358, 359, 363, 372, 373, 377, 382, 384, 395, 398, 403, 418, 424 Au nanoplates 235-242 growth conditions of 252-255 growth mechanism of 255-261 Au nanoprisms 64 Au nanospheres-embedded open nanostructures 278-280 Au NBP-embedded hollow nanostructures 293-296 nanoframes 296-299 Au NR-embedded open nanostructures 280 Au NRs AU@Ag core-shell nanocuboids 141-143 AuAg dumbbell nanostructures 143 - 145

Plasmonic Metal Nanostructures: Preparation, Characterization, and Applications, First Edition. Caixia Kan. © 2024 WILEY-VCH GmbH. Published 2024 by WILEY-VCH GmbH.

Au NRs (contd.) (AU@Ag NR)@SiO₂ 145–150 precise growth 134–137 Au UNWs critical size effect 203–204

b

bias voltages 334–339, 347, 361
bimodal size distribution 188
bis(*p*-sulfonatophenyl)phenylphosphine dihydrate dipotassium (BSPP) 243
Boltzmann distribution law 4
Bragg's law 104, 105
bromide ions 229, 239, 240
bulk plasmon 10–13, 16, 23, 49, 84

С

carbon dioxide reduction 83, 381-383 carbon monoxide stripping 387 Cassius Au purple 41 cetyltrimethylammonium bromide (CTAB) 116, 134-139, 141-143, 146-148, 150, 152, 167, 168, 170, 196, 229, 230, 232, 238-240, 250-252, 282, 285, 289, 420 cetyltrimethylammonium chloride (CTAC) 137, 139, 141-143, 149, 150, 152, 158, 165, 168-170, 239, 250, 251 chemical etchant 271, 272 chemical interface damping 390 chemometric methods 98 chemoselective reduction 395 circularly polarized light (CPL) detector 355.356 commutator method 387 computational electrodynamics simulations 280 conductive films conductivity performance 210-213 Cu nanowire film stability 208-209 electromagnetic shielding 213-216 NIR temperature control 216-218 preparation approach 206–208 conventional (HR)TEM mode 110 co-reduction method 157-159 core-shell nanostructures 139-140 Ag 149-152 AuAg 152-156 AU@Ag core-shell nanocuboids 141-143 AuAg dumbbell nanostructures 143-145 (AU@Ag NR)@SiO₂ 145-150

core-shell structure mesoporous SiO2 coating metals 321-323 plasmonic properties of 323 TiO₂ coating metal 323–325 coupled nanostructure 60, 71, 76, 412, 416, 420-421 coupling effect complex structure 71-76 multilayer nanostructure 76-78 nanocubes 65-67 nanoprisms 64-65 nanorods 67-71 nanospheres 60-63 Cu nanoplates 226, 249-251 Cu nanostructures-directed hollow nanostructures 276, 277 Cu nanowires growth mechanism 197–199 organic solvent-based synthesis 196-197 overgrowth 199-201 water-based synthesis 194-195

d

DCPM method 78 dealloying 114, 117, 164-167, 271-274, 286, 383, 393 delocalization 109 dielectric function effect 49-51 dielectric properties dielectric function effect 49-51 Drude-DCP model 46–49 Maxwell-Garnett effective medium theory 44-46 dimethylformamide (DMF) 250, 379 direct catalysis 391 discrete dipole approximation (DDA) 55-57, 78, 293-296 distinct transversal modes (T1-T3) 58 Drude-DCP model 46-49 Drude-Lorentz model 3, 42-44 Drude model 3-5, 7, 11, 42 Drude-Sommerfeld model 4

е

electrical SPP excitation 16–19 electric field enhancement 23, 25–29, 71, 73, 74, 76–78, 137, 140, 226, 248, 280, 281, 353, 431 electrocatalysis 372–373 carbon dioxide reduction 381–383 composition effects 375–377

crystalline facets 374-375 electrochemical surface area (ECSA) 386-387 ethanol electrooxidation 383-384 over-potential 385-386 oxygen reduction reaction (ORR) 377-381 size effect 373–374 Tafel-slope 387-388 electrochemical surface area (ECSA) 385-387 electroluminescence (EL) 18, 118, 120, 121, 314, 317, 318, 334, 335, 338, 339, 346 - 350electromagnetic shielding conductive films 204-218 NWs-based publications 185-186 one-dimensional metal nanowires 187-204 electromagnetic signal 7 electromagnetic waves 4, 6-8, 12, 20, 34, 55.138 electron beam 13, 19, 23-25, 101-105, 108, 113, 116, 119, 189, 203, 246, 247.416 electron-beam lithography (EBL) 64, 416 electron diffraction patterns 167 electron energy loss spectrometry (EELS) 19, 23–25, 76, 77, 102, 113, 119, 219 electron microscopy scanning electron microscope (SEM) 105-109 transmission electron microscope (TEM) 102 - 106electro-photoluminescence (EPL) 338 energy dispersive spectroscopy (EDS) 103, 115, 148, 158, 159, 204, 396 energy propagation length 11 Etchegoin's model 47 ethanol electrooxidation 383, 384 Ewald sphere 104, 105 excited-state absorption (ESA) 343

f

Fabry-Perot cavity 17, 34, 67, 336 fcc nanoplates 227–251 finite-difference time-domain (FDTD) 12, 13, 26, 49–51, 55–58, 63, 65–67, 70–72, 78, 113, 138, 248, 297, 298, 343, 365, 413, 420, 431, 432 flexible transparent conductive films (FTCFs) 193, 205, 207, 208, 210, 211, 214–216 focused laser beam 209 free electron gas dielectric function 5–7 Drude model for 3–4 full width at half maximum (FWHM) 50, 137, 138, 154, 281, 283, 284, 314, 334, 335, 355, 360, 365, 432

g

galvanic replacement 271–272 Gan equation 53–54 gap plasmons 60, 67 graphene-enhanced Raman scattering 423

h

HAADF-STEM imaging 110, 283 hard-templating synthesis 171-173 hexadecyltrimethylammonium chloride 165 high angle annular dark field (HAADF) detector 76, 110, 113, 290 hollow nanostructures carving of solid nanostructures 270 directed growth 273 Pd nanostructures-directed 274-276 reduction and galvanic replacement 272-273 template deposition 270-271 hot-electron intraband emission 340-341 hot-electron photodetection graphene 356-359 metamaterials 354-356 optical antennas 361-362 other structures 363-365 Schottky barrier 353-355 hot electrons effect 29 new energy 29-32 photoelectric device 32-33 plasmonic nanolaser 33-34 hot electron transfer (HET) 31, 32, 35, 314, 341-353, 355, 358, 389-392 hydrogen evolution reaction (HER) 307, 381, 385, 404 hydrothermal approaches 232-233 hydrothermal synthesis 197

i

indirect catalysis 391 in-situ electron microscope 113–118

j

Joule heating effect 347

k

kinetic isotope effect 394 Kretschmann configuration 14 Kretschmann geometry 14, 15

l

Lambert's law 85-86 Landau damping 3–5, 12, 29, 32, 33, 333, 390 Landau damping effect 3, 12 light-emitting device antenna-coupled light emission 334-339 hot-electron intraband emission 340-341 hot-electron transfer induced by plasmon 341-345 light emission enhanced by hot-electron 345-346 light modulation application 351, 353 ZnO:Ga MW light source 346-350 light irradiation wavelength 242 liquid-cell AC-STEM 116, 117 localized surface plasmon of nanoparticles 19-22 localized surface plasmons (LSP) 13, 15, 19-22, 25, 28-32, 35, 42, 51, 53, 60, 65, 92, 311, 317 local surface plasmon resonance (LSPR) 23, 25, 26, 34, 48, 65, 66, 96, 97, 113, 170, 201, 226, 248, 293, 294, 296, 297, 306, 308, 314, 317, 323, 333, 341, 346, 363, 389, 394, 395, 404, 413, 425, 429-432 longitudinal dipolar mode (L1) 58, 76 Lorentzian formula 71 Lorenz-Mie-Debye theory 20 Lorenz-Mie theory 20

m

Maxwell-Garnett effective medium theory 44–46 Maxwell's equations 7–9, 20, 45, 53, 56 Mayer rod 206, 207 3-mercaptopropionic acid (MPA) 69 metal-oxide semiconductor 34, 306–311 metal-perovskite quantum dots 314–317 metal-perovskite semiconductor 311–314 metal-two-dimensional (2D) materials 317–321 metal-vacuum interface propagation depth 12–13 propagation length 11–12 methanol 242, 373, 375, 383, 384, 395 Mie theory, for nanosphere 52–53 modified Stöber method 146, 322 multiple step methods 174–175

n

NaCl decoupling method 121 nanobelts 237, 258 nanocages 71, 268, 269, 274, 276, 284–286, 293, 299, 307, 308 nanocubes 65–67 nanoframes 282–283 nanoparticle periodic table 373 nanoprisms 64–65 nanorods 67–71 nanorods multimers 73 nanosphere 52–53 near-band edge (NBE) emission 345 NIR temperature control 216–218 nonradiative decay 19, 23, 334, 346, 354, 391

0

1-octadecanethiol (ODT) 62, 63, 320 1,8-octanedithiol (ODT) linkers 62, 420, 421 oleylamine (OLA) 158, 196, 197, 202, 203, 276 1D metamaterial perfect absorber (MPA) 355 open nanostructures Au atoms on Ag nanostructures 288–293 Au nanobipyramid-embedded 280–288 Au nanosphere-embedded 278–280 Au NR-embedded 280 optical property analysis Gan equation 53-54 isolated nanoparticles 51-54 Mie theory 52-53 numerical simulation 54-60 optoelectronic circuitry 16 organic solvent-based synthesis 196–197 Ostwald ripening process 188, 314 out-of-phase coupling 61, 62 oxygen reduction reaction (ORR) 375-381, 385, 386, 404

р

P-AuAg NRs 168–170 Pd nanostructures 274–276 photocatalysis organic compounds decomposition 392–393

plasmon-induced hot-electron transfer 389-392 small nonpolar molecules 394-396 thermal and nonthermal effects 396-397 photocatalytic CO₂ reduction 26, 324 photochemical synthesis 228, 233-235, 242-245 photoluminescence (PL) 100, 121, 315-318, 337, 338, 341, 345, 346, 349, 351.352 photoluminescence intensity 317 planar dielectric-metal interface 11, 19, 53 plasma resonance-enhanced Raman 92 plasmon coupling 62, 63, 67, 71, 73, 74, 417, 420, 424 plasmon energy dispersion 23 plasmonic nanofluid system 403 plasmonic nanolaser 33-34, 317 plasmonic nanostructures 346 absorption spectrometer 85-89 surface-enhancement Raman scattering 89-100 plasmon-induced hot-electron transfer (PHET) 32, 33, 341, 343, 345, 356, 366, 389-392 plasmon-induced interfacial charge-transfer transition (PICTT) 32, 33, 343, 366, 390 plasmon-induced resonant energy transfer (PIRET) 342, 343, 366 plasmon-mediated method 233 plasmon sensing 131, 281, 430-433 polyol synthesis 188, 232, 252 porous nanorods AuAg 164-168 chemical stability 168-170 porphyrin molecule 120, 121 precise growth of Au nanobipyramids 137-139 propagation depth 12–13 propagation length 11-12 pyrrolidone unit 232

q

quadrupole plasmon resonances 255 quantum limit 336 quantum mechanics 4, 90 quasi electrostatic model 22

r

Raman spectroscopy 28, 89–92, 94, 95, 131, 132, 430 Rayleigh scattering 90, 91, 363 reduction replacement reaction 272–273 resonance absorption 21, 50, 52, 138, 308, 323, 363 resonance plasmon coupling 73 resonant energy transfer (RET) 25, 122, 314, 342 resonant frequency 15, 20, 21, 42, 333

S

SAED patterns 106, 189, 228, 230, 241, 255, 256.287 scanning electron microscopy (SEM) 17, 63, 64, 66, 72, 93, 95, 102, 105-110, 119, 142, 189, 191, 195, 196, 198, 204, 205, 207, 208, 233, 241, 242, 252, 253, 256, 279, 295, 310, 317, 318, 322, 334, 335, 343, 344, 346, 349, 350, 353, 356, 357, 361-365, 394, 413, 416 scanning near-field optical microscopy (SNOM) 14, 15, 19, 78, 84, 225 scanning transmission electron microscope (STEM) 19, 23-25, 76, 77, 103, 109-113, 115-117, 148, 150, 153, 158, 159, 161, 165, 167, 168, 225, 282, 283, 287, 290, 324, 396 scanning transmission electron microscopy (STEM) mode 110 Schottky barrier 26, 307, 319, 351, 353-355, 361, 390 Schottky junction 30, 306, 325, 344 shell-isolated nanoparticle-enhanced Raman spectroscopy (SHINERS) 95, 100, 430 ship-in-a-bottle method 174, 175 silane-mediated approach 203 skin depth 6, 12–13, 30, 215, 216 sodium dodecyl sulfate (SDS) 323 soft-template synthesis 170, 173 solar energy 30, 31, 131, 165, 314, 371, 372, 388, 398, 402 solar vapor generation (SVG) heat localization 402-404 plasmon-enhanced absorption 398-402 solvo-thermal approaches 232-233 solvothermal synthesis 197, 276, 376 spectral analysis 84, 85, 433 spectrometer device 86-87 star-like microplates 258 STEM 110.113 STM induce luminescence 118-122 Stokes Raman scattering 90, 91 subnanometer electron beam 19 sub radiation 71, 76

supersaturation 190, 236 surface enhanced Raman spectroscopy (SERS) 308 coupled nanostructure 420-421 edge and tip hot spot 413-417 for molecular vibration Fingerprint 425-426 nanocavity and porous nanostructure 417-420 other catalytic reaction 430 other substrates 421-424 plasmon sensing 430-433 real-time detection 426-429 surface-enhancement Raman scattering chemical warfare agents 99-100 in disease diagnosis 98–99 food safety 99 history and principle 89-92 surface plasmon (SP) 333 detection 23-25 electrical SPP excitation 16-19 excitation configurations 14 localized surface plasmon of nanoparticles 19-22 optical excitation 13-16 other supports 22 surface plasmon amplification by stimulated emission of radiation (SPASER) 33 surface plasmon effects electric field enhancement 25-29 hot electrons effect 29-34 surface plasmon polaritons (SPP) 7-16, 19, 21, 25, 34, 35, 67, 312, 333, 335, 430, 431 surface plasmon resonance (SPR) 21, 23, 25, 26, 28, 35, 41, 42, 49, 50, 54, 56, 57, 60, 62, 65-67, 69-71, 73, 76, 78, 88, 89, 92, 114, 131–133, 136–139, 146, 148, 154, 156, 163, 165-167, 173, 175, 200, 201, 204, 226, 230, 235, 244, 255, 293, 307, 308, 314, 333, 371, 372, 389-392, 400, 411-413, 415, 417, 418, 420, 424, 426, 430, 431, 433

t

 Tafel-slope
 385, 387–388

 Tamm plasmons (TPs)
 359, 360

Tauc function 87 TEM and SEM aberration correction 109-110 in-situ electron microscope 113-118 STEM 110-113 STM induce luminescence 118–122 thermal annealing method 158-164 TiO₂ coating metal 323–325 tip-enhanced Raman spectroscopy (TERS) 28, 94, 95 TM dipole 55 transmission electron microscope (TEM) 23, 58, 61, 67, 68, 70, 75, 84, 95, 102-107, 109-111, 114-117, 133, 136, 138, 143-151, 153, 154, 161-163, 166, 172, 173, 189, 195, 196, 202, 212, 225, 230, 231, 233, 234, 236, 237, 239, 241, 245, 250, 254, 258, 260, 275, 279, 280, 282-287, 290, 296, 297, 309, 310, 313-315, 317-320, 322, 324, 325, 345, 363, 364, 382, 387, 415, 418, 419, 421 transversal dipolar mode (T1) 58 transverse electric TE mode 9 transverse magnetic (TM) wave 8,9 trisodium citrate 230, 233, 235

и

ultrathin metal nanoframes 282, 283, 297 ultraviolet light 86, 101 UV-Vis-NIR spectrometer 23, 85, 86, 225

W

water-based synthesis 194–196 wavelength illumination 363 Wulff principle 116

у

yolk-shell nanostructures (YSNs) hard-templating synthesis 171–173 multiple step methods 174–175 self-template synthesis 174 soft-template synthesis 173

Ζ

zinc phthalocyanine (ZnPc) 120-122, 339