Index

a

AAO templated carbon materials (AAO-TCs) 61
ABA configuration 4
acetonitrile 173, 174
activated carbon 103
adsorption behavior CMS and GMS 139–140
aerogels 117
alkali activation process 47
alkoxide species 169
alumina (Al_2O_3) nanoparticles 106
aluminum anodic oxide (AAO) 61
aluminum oxide (Al_2O_3) 28
anodic aluminum oxide (AAO) 105

b

basal plane 146
benzoic acid 169
bilayer graphene 16
biological sensors 32
biosensors 203–204
BN-CNT hybrid material 57
boron nitride (BN)-rGO 57
buckytubes 40
bulk modulus 147, 148, 150
bulk shape GMS 134–136

c

C_{60} 105
CaO 112
capillary pressure 118
carbon 1
carbon allotrope 1
  of multiple carbon hybridization states 6–7
  sp-carbon allotropes 6
  sp^2-carbon allotropes 1–5
  sp^3-carbon allotropes 1
carbon black 103
carbon cathode design 194
carbon cloths 134
carbon-coated template 124
  graphene mesosponge (GMS) 136–138
carbon-coating method 137
carbon dots (CDs) 58
carbon fibers 134
carbon inverse opals (CIOs) 61
carbonized polymer dots (CPDs) 58
carbon materials 104, 134, 171–174
  conceptual foundation 213
  Li-O_2 batteries 183–194
carbon mesosponge (CMS) 45, 107, 168, 180–183
  hydrophobicity of 138
carbon nanotubes (CNTs) 2, 3, 40, 103, 105
carbon quantum dots (CQDs) 58
carbon schwarzites 41, 71
carbyne 6
catalyst-assisted CVD 10
catalyst supports 167–169
catalytic systems 204
chemical exfoliation 25
chemical stability GMS 142–146

chemical vapor deposition (CVD) 10, 11, 60, 105
GMS 111–115
CNovel 104, 169
coefficients of performance (COPs) 201
commercial graphene products 29–31
Coulombic interactions 57
cryogels 117
cS(79)/wCMS 181
Cu 27–29
cumulene-type carbynes 6
Curie–Weiss analysis 155
cyclic voltammetry (CV) 174
cylindrical nanocavities 61

d

D band 145
dehydrogenative oxidation reactions 97
density of states (DOS) 151
developed stacking 122
diamond-like carbons (DLCs) 6
films 6
Dirac point 151
domain size 97–99
GMS 126–127
dopamine 57
drying-induced shrinkage 116

e

edge sites 184, 185
GMS 125–126
elasticity GMS 146–150
electrical conductivity 138
GMS 141–142
electrical double layer 172
electric double-layer capacitors (EDLCs) GMS 150–154
electrocatalysis 49
electrochemical capacitance 173
electrochemical capacitors 171
electrochemical energy storage 205
electrochemical exfoliation 26
electrochemical systems 205
electrodes 168, 176, 178–181
energy density 173, 175
epitaxial growth 26–29
epitaxial synthesis 46, 59, 60
Euler's theorem 5
external stimuli 122

f

FAU zeolite 66
ferromagnetism 32
few-layer graphene 32–33
field-effect transistors 31–32
flame method 11
flexible nanoporous materials 150
fuel cells 194–197
fuel cell vehicles (FCVs) 106
fullerenes 3
full width at half maximum (FWHM) 20

g

gas-phase carbonization 10–11
germanium (Ge) 28
GF-PMMA 74
GMS-Ru 188–191
GO nanosheets 54
Gouy-Chapman model 151
graphdiyne 7
graphene 3, 4, 15, 40
bilayer few-layer, and multi-layer graphene 16
definition of 15, 213
graphene layer 16
graphite 17
structural characterization of 17–24
turbostratic carbons 16–17
graphene-based carbon materials 214
graphene-based materials
application of 31
few-layer graphene 32–33
monolayer graphene 31–32
suitable for 33
2D graphene and 3D architectures 34
graphene-based material synthesis 24–25
bottom-up methods 26–29
top-down methods 25–26
graphene-based 3D carbon 105, 215

graphene-based 3D materials
defects 94
domain size 97–99
HT-TPD 94–97
stacking number 99–101
topological defect analysis 101–102
graphene-coated porous silica spheres (G/PSS) 137, 138, 203–204
graphene domain size 97–99
graphene foam (GF) 42, 62
graphene fragmentation 59
graphene fragment-based methods 46
graphene mesosponges (GMS) 44, 103–104, 214
adsorption behavior 139–140
bulk shape 134–136
carbon-coated template 136–138
chemical stability 142–146
chemical vapor deposition 111–115
development history 105
domain size 126–127
edge sites 125–126
elasticity 146–150
electric conductivity 141–142
electric double-layer capacitors 150–154
heteroatom doping 132–134
hydrophobic nature of 168
Li-O_2 batteries 183–194
magnetism 154–157
pore wall and stacking number 123–125
porous texture 123
structure 122
supercapacitors 171–179
surface characteristics of 168
synthesis 108
template 108–111
template removal 115–118
topological defects 127–131
zipping reactions 118–122
graphene nanodots 4
graphene nanoribbons (GNRs) 4, 41
graphene oxide (GO) 21, 135
graphene oxide-based bottom-up synthesis 49, 51–53, 55, 57
graphene quantum dots (GQDs) 4, 58
graphite 16, 17
graphyne 7

h

hard carbon 9
heat pump 199–203
heat treatment 142
Helmholtz layer 172
heteroatom-doped carbon materials 132
heteroatom doping GMS 132–134
hexagonal boron nitride (h-BN) 29
hexagonal graphite structure 4–5
highly ordered pyrolytic graphite (HOPG) 25
highly oriented pyrolytic graphite (HOPG) 10, 184
high-temperature range temperature-programmed desorption (HT-TPD) 18, 93–97, 107, 129, 168
H_2-treated AC 174
hydrazine monohydrate 52
hydrocarbon precursors 64
hydrodesulfurization process 180
hydrofluoric acid (HF) 115
hydrogen evolution reaction (HER) 97
hydrogen peroxide (H_2O_2) sensor 203
hydrothermal treatment 55

i

Iceberg Model 7, 8
ice-templating effect 117
in-plane topological defects 185
in silico zeolite-templated carbon (ZTC) models 65

l

Li-ion batteries (LIBs) 197–199
linear Dirac dispersion 31
liquid-phase carbonization 9–10
liquid-phase exfoliation 24, 25
lithiation 180

lithium–oxygen (Li-O_2) batteries 168
carbon materials in 183–194
GMS in 183–194
lithium-sulfur (Li-S) batteries 180–183
low-crystallinity carbon materials 8

m

Mackay crystals 41
magic angle 32
magnetic measurements 45
magnetism GMS 154–157
material's structure 103
mercury 147
mesopores 104
mesoporous carbons 104
mesoporous graphene (MG) 74
mesoscale enables 214
metallic gold cluster catalysts 170
metal-templated CVD approaches 75
metal–organic frameworks (MOFs) 46, 47
micromechanical exfoliation 24, 25
molecular fragment–based bottom-up synthesis 58–59
molecular fragment-based methods 46
monodisperse porous silica spheres (PSSs) 137
monolayer graphene 31–32
sheets 106
monolithic carbon 134
multilayer graphene sheets 106
multiple carbon hybridization states carbon allotrope 6–7
multi-walled carbon nanotubes (MWCNTs) 2, 40, 120

n

nanosponge 201
N-CMS/N-GMS synthesis process 133
N-doped MG 74
negative Gaussian curvature 5
Ni-containing porphyrin dimer with two diacetylene tethers (Ni_2-CPD_{Py}) 49
Ni-CVD processes 105
Ni-G 73, 74
nitrogen-doped CMS/GMS 133
non-aqueous Li-O_2 batteries 131
np-GMS 175–178
np-GMS displayed well-distributed mesopores 135
nuclear magnetic resonance (NMR) 173

o

O-functional groups 59
open circuit potential (OCP) 175
ordered carbonaceous frameworks (OCFs) 48, 62
ordered mesoporous carbons (OMCs) 61, 105
organic electrolytes 151
organic polymeric architectures 47
organic synthesis 168
oxidation resistance 144–146
oxide ceramic template 75–76
oxygen evolution reaction (OER) 127, 183
oxygen reduction reaction (ORR) 75, 127, 183

p

palladium-catalyzed biphenylation 40
palladium (Pd) nanoparticles 168
P-doping 132
platinum (Pt) nanoparticles 168
point-of-care testing (POCT) devices 203–204
poly(acrylic acid) (PAA) 57
polyacrylonitrile (PAN) 9
poly(dimethyl siloxane) (PDMS) 74
polymer electrolyte fuel cells (PEFCs) 108
poly(methyl methacrylate) (PMMA) 73, 74
poly(vinyl alcohol) (PVA) 54
polyyne-type carbynes 6
pore wall 123–125
porous graphene 57, 58
porous precursors 46
porous silica spheres (PSSs) 137

potential of zero charge (PZC) 134
propylene carbonate (PC) 135, 173
pulsed chemical vapor deposition (P-CVD) technique 68

r

Raman analysis 145
Raman spectroscopy 22, 93, 94
  GMS 130
reduced GO (rGO) 49
  synthetic pathways 51

s

Scherrer equation 98
schwarzite-like carbon materials 66
shuttle effect 180
single-crystal Ni 27
single-walled carbon nanotubes (SWCNTs) 2, 40, 107
SiO_2 nanoparticles 106
sodium hydroxide (NaOH) 115
soft carbon 9
sol-gel method 116
solid-phase carbonization 8–9
sp^2-based carbon allotrope synthesis 7–8
  liquid-phase carbonization 9–10
  solid-phase carbonization 8–9
sp-carbon allotropes 6
sp^2-carbon allotropes 1–5
sp^3-carbon allotropes 1
sp^2-carbon nanostructures 120
stacking number 99–101, 123–125
stress-relaxation effect 199
supercapacitors 171–175
  GMS in 175–179
surface-assisted Ullmann coupling reaction 58

t

temperature control 51
templated carbonization 105
templated synthesis 60–63
template-guided synthesis 214
template removal GMS 115–118
thermal annealing process 50
thermal reduction process 51
thermoplastic polymers 9
3D building blocks 57
three-dimensional carbon materials 213
  challenges 76–77
  conversion methods 47
  epitaxial synthesis 59–60
  geometric considerations 39–42
  graphene oxide-based bottom-up synthesis 49–57
  molecular fragment-based bottom-up synthesis 58–59
  oxide ceramic template 75–76
  plausible advantages of 42–46
  synthetic strategies 46
  templated synthesis 60–63
  3D metal templated synthesis 72–75
  top-down strategies 47
  zeolite templated synthesis 63–72
3D cross-linked polymers 9
three-dimensional (3D) graphene 103
3D graphene architectures 34, 204, 205
3D metal templated synthesis 72–75
3D porous graphenes 21, 22
three-dimensional transmission electron microscopy (3D-TEM) 131
TMS-modified mesoporous silica (TMS-MPS) 113
TMS-modified SiO_2 137
topological defect analysis 101–102
topological-defect-rich GMS 131
topological defects GMS 127–131
transmission electron microtomography 196
transparent conductive electrodes 32
trial-n-error approach 62
trimethylsilyl (TMS) 113, 137
turbostratic carbons 16–17
2D graphene and 3D architectures 34

v

vacancy 94
Voronoi tessellation 126

w
wNGs 40

x
xerogels 116
X-ray diffraction (XRD) 17, 93, 97, 98, 125, 213

y
Young's modulus of GMS 150
YP-50F 175

z
zeolite-templated carbons (ZTCs) 43, 66–67, 105, 173
zeolite-templated CVD methods 76
zeolite templated synthesis 63–72
zeolitic imidazolate MOFs 47
0D allotropes 58
zipping reaction 118, 167
  GMS 118–122
Zn-based MOF (ZIF-7) 129
ZnO quantum dots 129