Index

a

accent lighting 72
achromatic visual clarity 205–212

b

Berman *et al.* model 44
brightness 26
  Berman *et al.* model 44
  CIE 43–44
  Fairchild and Pirrotta's L^{**} model 45
  feature 43
  Fotios and Levermore model 45
  Helmholtz-Kohlrausch effect 41
  human visual system 41
  impression 41
  luminance channel 41
  WCCf 44
brightness matching experiment 212–218
brightness-luminance discrepancy 41

c

2D & 3D color gamut area 115
CAM02-UCS color difference 55
CAM02-UCS uniform 46–48
chroma difference 33, 116, 363
chroma difference formulae 47
chroma increment factor 60
chroma shifts 243
chromatic adaptation 28–29, 52, 145
chromatic visual clarity 204–212
chromatic visual clarity score (VC_c) 208
chromaticity
  criterion values 273–276
  semantic contours 274, 275
  white tone 72
chromaticity diagram
  u'–v 24
  applications 21
  coordinates 19
chromaticity difference 216
CIE brightness model 43–44
CIE color rendering index (Ra)
  flowchart 50
CIE tristimulus values 52
CIECAM02 color appearance model 41
CIELAB chroma difference 60
CIELAB color difference 45–46, 53
CIELAB color space 36–37
CIELAB values 53
circadian clock 338
circadian stimulus (CS) 338–344
classical approach
  theory of signal processing application 120–121
  visual color model application 121
cognitive color 29–31
cold white light sources 184–189
color appearance 28, 31, 357
  brightness models 41–45
  changing 33
  chromatic adaptation 28
  CIECAM02 model 37–41

Color Quality of Semiconductor and Conventional Light Sources, First Edition.
Tran Quoc Khanh, Peter Bodrogi, and Trinh Quang Vinh.
© 2017 Wiley-VCH Verlag GmbH & Co. KGaA. Published 2017 by Wiley-VCH Verlag GmbH & Co. KGaA.

color appearance (*contd.*)
CIELAB color space 36–37
color attributes, of perceived 26–27
color differences 45–46
color stimuli 26
perceived color differences 29
semantic interpretation and criterion values 276–277
similarity of 31
viewing conditions 28–29
color arrangement 131
color collection 101, 105, 108, 310
advantages and disadvantages 93
color constancy 28
color difference 91
CAM02-UCS uniform 46–48
chroma differences 29
CIELAB 45–46
description 131
semantic interpretation and criterion values 268–277
spider web diagrams 116
state-of-the-art 145–154
color discrimination 272
ability 35
indices 63
trade-off values 280
color fidelity 1, 32, 131, 309, 362
CIE color rendering index 49–52
CQS 52–53
CRI201 method 53–56
deficiencies 57
index R_f 56
LED light engines 320–323
philosophy 155
RCRI 57
semantic interpretation 270–272
color gamut 113
color gamut differences 243–246
color gamut index 155–156
R_g 62–63
CQS method 62
CRC 62
CSA 62
deficiencies 63
FCI 62
GAI 62
color gamut values R_g 133
color grouping
principles 114–125
quality 122–123
color harmony 35
color LEDs
spectral power distribution 302–305
temperature and current dependence of 299–300
color matching functions 17–19
color memory 30
color naturalness 32
color perception 2, 11, 92
color preference 241
food products 256–268
linear fidelity formula 195–196
makeup products 246–256
MCRI 190
quadratic formula 195–196
real room 234–246
trade-off values 280
with constrained linear formula 192–193
with unconstrained linear formula 194–195
color preference indices 32
color discrimination indices 63–64
color gamut indices 61–63
CQS Q_a 60–61
GAI 58
Judd's flattery index 57–58
MCRI 58–60
Thornton's 58
color quality 48–64
prediction potential and correctness 166–171
acceptable 14
achromatic visual clarity 204–212
and quantity 285
brightness matching experiment 212–218
chromatic visual clarity 204–212
color fidelity indices 49
color preference indices 57–61
color sources 132–140
colored object 141–142

colorimetric properties 228
computational methods 49–50
concept 31
correlated color temperature 218–225
correlation 177–189
correlation calculations 161
evaluation 130
impression 31–35
index formula 362
LED wavelengh 311–320
light source 278
methodology 159
metrics 7, 132
metrics and values 110
motivation and aim 201–204
of light sources 100–114
optimization 305–311
R_1-R_2-G-B_1-B_2-W-LED-configuration 327–333
real room, naturalness and vividness 234–246
research 3
RGB-W-LED configuration 323–327
semantic interpretation and criterion values 268–277
state-of-the-art of 154–159
subjective aspects 5
system 358
systematization 315–320
task of 91
type 31
viewing conditions 142–145
visual aspects 48–49
visual assessments 239
color quality optimization
for human centric lighting 335–338
Color Quality Scale (CQS) 52
color realness 32
color rendering capacity (CRC) 62
color rendering index 135
numeric scale 52
color rendering index (CRI R_a) 1, 2
color rendering indices 221
color science 17
color space 26, 27
CAM02-UCS uniform 46
state-of-the-art 145–154
color temperature preference, colorful object combinations 225–233
color temperatures 132
color vision
inter-observer variability 20
mechanisms 12
visual perception 11
color vividness 32
colored objects
state-of-the-art 141–142
colorful object combinations 225–233
colorfulness 26
colorimetric data 99, 112
colorimetric purity 24
colorimetry
u'–v' diagram 24
applications 21
basics of 16
CCT 22
chromaticity coordinates 19
color matching functions and tristimulus values 17
dominant wavelength 24
inter-observer variability, of color vision 20
MacAdam ellipses 24
cone
density 14
sensitivity curves 16
spectral sensitivities 15
types 15
cone surface area (CSA) 62
Constant current dimming (CCD) 301
cornea 12
correlated color temperature (CCT) 1, 21, 218, 219
colorful object combinations 225
correlated color temperature (T_{cp}) 49
computation method 51
correlation calculation 166
CQS Q_a 60
CQS Q_p 61
CQS method 62

CRI2012 53
  calculate 55
  components 53
  computation method 54
  flowchart 54
  principles 53
  RMS formula 55
  test colors 55

d
dimming method 300–302
dominant wavelength 23, 24
double Gaussian model 306
driving electronics 288

e
electronics
  control and regulation 289–290
Energy Star Eligibility Criteria 286

f
Fairchild and Pirrotta's L^{**} model 45
feeling of contrast index (FCI) 62
fluorescent lamps 133
food products 256–268
Fotios and Levermore model 45
fovea 14

g
gamut area index (GAI) 58, 62

h
HCL concept
  visual and non-visual aspects 286
Helmholtz-Kohlrausch effect 41
heterochromatic brightness matching experiment 42
horizontal illuminance 33, 34
hue 26
hue circle diagram 118
human centric lighting (HCL) 3, 364
  aspects of 336
  co-optimizing circadian aspects 344–348
  color quality optimization for 335–338
  design concept for 337
  spectral transmittance 348–354
human eye
  structure 13
human vision mechanisms 42
human visual system 11

i
illuminance values (lx) 210, 211
indoor lighting technology 283
industrial electrification 335
inter-observer variability 78–83
intrinsically photoreceptive retinal ganglion cell (ipRGC) 339–341

j
Judd's flattery index 57–58

l
LED 288
LED light engines
  chroma enhancement 320–323
  R_1-R_2-G-B_1-B_2-W-LED-configuration 327–333
  RGB-W-LED configuration 323–327
LED light sources 2
LED luminaries 283
  in real applications 315
LED-luminaire Lunexo 289
lens 12
light source
  electromagnetic radiation 11
  spectral design 33
  white tone 71
light source spectra 3
light sources
  cold white 184
  color quality 100
  colorimetric properties 216, 220
  relative spectral power distributions 149, 150
  relative spectral radiance 205
  state-of-the-art 132
  warm white 178

light sources emitting 339
lighting dynamic properties 284
lighting engineering 357–364
lighting engineers 3
lighting industry 71
lighting practice 277–280
lighting quality optimization 5
lighting quantities 284
lighting systems 129
lightness 26
LMS cone signals 223, 230
long-term memory colors 30, 33
luminaire's luminous flux 291
luminance channel 16, 41
luminous efficiency function ($V(\lambda)$) 16

m

MacAdam ellipses 24
makeup products 246–256
MCRI, *see* memory color rendition index (MCRI) 59
melatonin 339–340
memory color quality index (MCRI) 59, 190
memory colors 157
metameric white light sources 212
modern color metrics 123
multi-input multi-output (MIMO) system 303
multi-LED spectrum 348
multidimensional scaling (MDS) 164

n

naturalness 241
  food products 256
  makeup products 246–256
  real room 234
  white light chromaticity 84
nCRI 53
non-uniform color space 51

o

object colors 125
  database 98
oil colors 123
optic disk 13
optic nerve 13
optimization 318, 319
optimization of illuminating systems 3

p

Pearson's correlation coefficients 253
Perceived Adequacy of Illumination (PAI) 3
perceived color attributes 26
phases of daylight 22
photometric quantities 16
photoreceptors 14
prediction
  of color preference 241
  of naturalness 241
  of vividness 240
preferred colors 157
pulse width modulation (PWM) 301

r

R_g metric 360
radiometric quantities 16
RCRI 57
reference light source 32, 52
retina 12, 13
rod density 14
root mean square (RMS) 53, 55

s

S-cone signals 354
saturation 26
sclera 12
scotopic vision 14
Solid State Lighting (SSL) 286
solid-state-lighting products 361
spectra of Planckian radiators 111
spectral luminous efficiency function $V(\lambda)$ 1
spectral power distribution (SPD) 75, 213, 302
spectral reflectance
  art paintings 97
  curves 221, 237
  flowers 94
  skin tones 96

spectral sensitivities 15
spider web diagrams 118
suprachiasmatic nucleus (SCN) 339

t

test color samples (TCS) 50–52, 103, 114
thermal management 290–291
Thornton's color preference index 58
tri-stimulus values 17, 145
tungsten halogen lamps 133
tungsten incandescent lamps 133
two lighting situations 220

u

unique white
  chromaticity of 76
  L-M and L+M-S signals 77
  location of 74

v

visual clarity 35, 204, 206, 207
  analysis and modeling 208
  variables 209
visual color quality, *see* color quality
visual experiments 160
visual interval scale variables 238
vitreous body 12
vividness 240
  makeup products 246
  real room 234

w

Ware and Cowan Conversion Factor formula (WCCF) 44
warm white light sources 178
warm white pc-LEDs
  color difference 297
  current depenence 297–298
  temperature dependence 295
WCCF, *see* Ware and Cowan Conversion Factor formula (WCCF)
white light chromaticity 84
white tone
  chromaticity 71–73
  inter-observer variability 78
  perceived brightness 85
  preference 83, 358
  unique white 74
white tone chromaticity matching discrepancy 81
white tone quality 35