

CONTENTS

Preface	xi
Notation	xiii
Video Clip Examples of Gloss in Different Applications	xix
Disclaimer	xxi
 <i>Chapter 1</i>	
Introduction	1
 <i>Chapter 2</i>	
Light Reflection from Ideal Surface	5
2.1. Electromagnetic theory of light waves	6
2.1.1. Wave equation	6
2.1.2. Maxwell equations for free space	8
2.2. Light irradiance	13
2.3. Light polarization	14
2.4. Real refractive index	16
2.5. Group velocity	19
2.6. Normal reflection of light	21
2.7. Light reflection at an oblique angle of incidence	25
2.8. Complex refractive index	31
2.9. Beer–Lambert law	39
2.10. Oblique angle reflection from light-absorbing isotropic media	40
2.11. Reflectance from anisotropic media	44
2.12. Specular reflection from nanostructured medium	46

Chapter 3

Light Reflection from a Rough Surface	53
3.1. Statistical surface roughness parameters	54
3.2. Light diffraction from finishing marks	58
3.3. Kubelka–Munk function for diffuse reflection	63
3.4. Specular reflection of laser beam from moderately rough surface	66
3.5. Specular reflection from surface with normal distribution of surface heights	69
3.6. Speckle pattern	71
3.7. Statistical parameters for specular gloss	75

Chapter 4

Specular Gloss	79
4.1. Visual appearance of a surface	79
4.2. Directionality of surface	85
4.3. Standardized method for specular gloss	87
4.4. Problems in the gloss measurement	95

Chapter 5

Light Sources for Gloss Measurement	103
5.1. Radiation laws	103
5.1.1. Geometrical consideration	104
5.1.2. Kirchhoff's law	108
5.1.3. Black body radiation	109
5.1.4. Grey body radiation	112
5.1.5. Stefan–Boltzmann law	113
5.1.6. Wien's displacement law	114
5.1.7. Planck's radiation law	116
5.1.7.1. Derivation of Stefan–Boltzmann constant (σ)	118
5.1.7.2. Derivation of constant (C_0) in Wien's displacement law	119
5.1.8. Brightness temperature	120
5.1.9. Colour temperature	123

5.2.	White light source (So) for standardized glossmeter	127
5.2.1.	Brightness and emissivity of tungsten	127
5.2.2.	Stability of tungsten as an So	130
5.2.3.	Spectral irradiance of incandescent lamp of standardized glossmeter	133
5.3.	Coherence and partial coherence of light	136
5.3.1.	Damping effect on function of electric dipole	138
5.3.1.1.	Light emission influenced by damping	143
5.3.1.2.	Light absorption influenced by damping	146
5.3.2.	Concept of coherence	149
5.3.2.1.	Time coherence	150
5.3.2.2.	Spatial coherence	152
5.3.3.	Coherence function and fringe visibility	155
5.3.4.	Coherence of thermal So	160
5.3.5.	Photon correlation	166
5.4.	Light-emitting diode	168
5.4.1.	Energy bands in semiconductors	169
5.4.2.	Radiative and non-radiative transitions	173
5.4.3.	Spectral broadening of luminescence spectra	177
5.4.4.	Light generation efficiency	179
5.4.5.	Electrical characteristics of LEDs	182
5.4.6.	Architecture of LED	184
5.4.7.	Frequency response of LED	186
5.4.8.	Spectral response of LED	187
5.5.	Laser	190
5.5.1.	Theory of inversion population – a paradox of equilibrium	190
5.5.2.	Lasing conditions	193
5.5.3.	Spectral profile of lasing radiation	197
5.5.4.	Laser beam directionality	199

5.5.5. Cavity modes	200
5.5.5.1. Longitudinal modes	200
5.5.5.2. Transverse modes	201
5.5.6. Electrical characteristics of semiconductor LD	207
5.5.7. Laser categories	209
Appendix A.5.1	210
Appendix A.5.2	211
Appendix A.5.3	213
Appendix A.5.4	214
Appendix A.5.5	215

Chapter 6

Detectors for Gloss Measurement	219
6.1. Principle to simulate human eye response in detectors	220
6.1.1. Basic structure of human eye	220
6.1.2. Optical properties of human eye	227
6.1.3. Hazards in human eye after excess of MPE	229
6.1.4. Standardized human eye	230
6.2. Semiconductor photodiode	231
6.2.1. Photovoltaic effect	231
6.2.2. Spectral response of PD	237
6.2.3. Electric response of PD	239
6.3. APD	241
6.4. Phototransistor	242
6.5. Photoarray	243
6.5.1. Basic principle of CTD	244
6.5.1.1. Principle of BBD	247
6.5.1.2. Principle of SCDD	248
6.5.1.3. Principle of BCCD	249
6.5.1.4. Principle of PCCD and P ² CCD	249
6.5.2. Charge-coupled photoarray	251
6.5.2.1. One-dimensional CCD array	251
6.5.2.2. Two-dimensional CCD array	252
6.5.2.3. Colour CCD array	254

6.6. Electric noise	255
6.6.1. Types of basic electric noise	255
6.6.2. Signal to noise ratio, noise figure and noise temperature	263
6.6.3. Noise in real materials and in electric components	265
6.6.4. Detecting limits of photodetectors	265

Chapter 7

Traditional Glossmeters	267
7.1. Spectral reflectance	267
7.1.1. Non-coherent spectral reflectance	269
7.1.2. Coherent spectral reflectance	274
7.2. Principle of reflectometer	275
7.2.1. Principle of spectral reflectometer	276
7.2.1.1. Monochromator	276
7.2.1.2. Specular reflectometer	281
7.2.1.3. Reflectometer for specular and diffuse radiation	284
7.2.2. Principle of laser reflectometer	286
7.2.3. Spectral ellipsometer	290
7.3. Spectrophotometer	295
7.4. Spectroradiometer	302
7.5. Goniophotometer	305
7.6. Spectrogoniometer	307
7.7. White light glossmeter	309

Chapter 8

Modern Glossmeters	315
8.1. Imaging spectrometers	317
8.2. Gloss measurement by LED and photodiode	318
8.3. Gloss measurement by laser and photodiode	324
8.4. Gloss measurement by laser and photoarray	325
8.4.1. Gloss measurement from planar surface	326
8.4.2. Diffractive optical element (DOE) based glossmeter	328

8.4.2.1.	Beam waist environment	329
8.4.2.2.	Basis for DOE – hologram imagery	334
8.4.2.3.	Wave optical treatment of DOE	340
8.4.2.4.	DOE as sensor element of diffractive optical glossmeter (DOG)	344
8.4.2.5.	Analysis of DOE image in gloss measurement	354
8.4.2.6.	Gloss measurements at normal incidence	357
8.4.2.7.	Miniaturization of DOG	364
8.4.2.8.	Gloss of plastics	367
8.4.2.9.	Gloss of metals	377
8.4.2.10.	Gloss of ceramics	388
8.4.2.11.	On-line measurement of gloss of print	396
8.4.2.12.	Offbeat applications of DOG	404
References		413
Subject Index		481