

Contents

List of Abbreviations	XXIII
------------------------------------	--------------

Part A Basic Principles and Materials

1 The Properties of Light

<i>Richard Haglund</i>	<i>3</i>
1.1 Introduction and Historical Sketch	4
1.2 Parameterization of Light	6
1.3 Physical Models of Light	9
1.4 Thermal and Nonthermal Light Sources	14
1.5 Physical Properties of Light	17
1.6 Statistical Properties of Light.....	24
1.7 Characteristics and Applications of Nonclassical Light.....	27
1.8 Summary	29
References	29

2 Geometrical Optics

<i>Norbert Lindlein, Gerd Leuchs</i>	<i>33</i>
2.1 The Basics and Limitations of Geometrical Optics	34
2.2 Paraxial Geometrical Optics.....	39
2.3 Stops and Pupils	60
2.4 Ray Tracing	61
2.5 Aberrations	67
2.6 Some Important Optical Instruments	72
References	84

3 Wave Optics

<i>Norbert Lindlein, Gerd Leuchs</i>	<i>87</i>
3.1 Maxwell's Equations and the Wave Equation	88
3.2 Polarization	102
3.3 Interference	108
3.4 Diffraction	123
3.5 Gaussian Beams	143
References	154

4 Nonlinear Optics

<i>Aleksei Zheltikov, Anne L'Huillier, Ferenc Krausz</i>	<i>157</i>
4.1 Nonlinear Polarization and Nonlinear Susceptibilities	159
4.2 Wave Aspects of Nonlinear Optics	160
4.3 Second-Order Nonlinear Processes	161
4.4 Third-Order Nonlinear Processes	164

4.5	Ultrashort Light Pulses in a Resonant Two-Level Medium: Self-Induced Transparency and the Pulse Area Theorem.....	178
4.6	Let There be White Light: Supercontinuum Generation	185
4.7	Nonlinear Raman Spectroscopy	193
4.8	Waveguide Coherent Anti-Stokes Raman Scattering	202
4.9	Nonlinear Spectroscopy with Photonic-Crystal-Fiber Sources	209
4.10	Surface Nonlinear Optics, Spectroscopy, and Imaging	216
4.11	High-Order Harmonic Generation	219
4.12	Attosecond Pulses: Measurement and Application.....	227
	References	236

5 Optical Materials and Their Properties

*Matthias Brinkmann, Joseph Hayden, Martin Letz, Steffen Reichel,
Carol Click, Wolfgang Mannstadt, Bianca Schreder, Silke Wolff,
Simone Ritter, Mark J. Davis, Thomas E. Bauer, Hongwen Ren,
Yun-Hsing Fan, Shin-Tson Wu, Klaus Bonrad, Eckhard Krätzig,
Karsten Buse, Roger A. Paquin*

5.1	Interaction of Light with Optical Materials	250
5.2	Optical Glass	282
5.3	Colored Glasses	290
5.4	Laser Glass	293
5.5	Glass–Ceramics for Optical Applications	300
5.6	Nonlinear Materials	307
5.7	Plastic Optics	317
5.8	Crystalline Optical Materials	323
5.9	Special Optical Materials	327
5.10	Selected Data	354
	References	360

6 Thin Film Optical Coatings

Detlev Ristau, Henrik Ehlers.....

6.1	Theory of Optical Coatings	374
6.2	Production of Optical Coatings	378
6.3	Quality Parameters of Optical Coatings.....	388
6.4	Summary and Outlook	391
	References	393

Part B Fabrication and Properties of Optical Components

7 Optical Design and Stray Light Concepts and Principles

Mary G. Turner, Robert P. Breault

7.1	The Design Process	399
7.2	Design Parameters	402
7.3	Stray Light Design Analysis.....	410
7.4	The Basic Equation of Radiation Transfer	412

7.5 Conclusion	416
References	416

8 Advanced Optical Components

<i>Robert Brunner, Enrico Geißler, Bernhard Messerschmidt, Dietrich Martin, Elisabeth Soergel, Kuon Inoue, Kazuo Ohtaka, Ajoy Ghatak, K. Thyagarajan.....</i>	419
8.1 Diffractive Optical Elements	419
8.2 Electro-Optic Modulators	434
8.3 Acoustooptic Modulator	438
8.4 Gradient Index Optical Components	440
8.5 Variable Optical Components	449
8.6 Periodically Poled Nonlinear Optical Components.....	459
8.7 Photonic Crystals	463
8.8 Optical Fibers	471
References	494

9 Optical Detectors

<i>Alexander Goushcha, Bernd Tabbert</i>	503
9.1 Photodetector Types, Detection Regimes, and General Figures of Merit.....	505
9.2 Semiconductor Photoconductors	510
9.3 Semiconductor Photodiodes	512
9.4 QWIP Photodetectors	527
9.5 QDIP Photodetectors	529
9.6 Metal–Semiconductor (Schottky Barrier) and Metal–Semiconductor–Metal Photodiodes.....	530
9.7 Detectors with Intrinsic Amplification: Avalanche Photodiodes (APDs)	532
9.8 Detectors with Intrinsic Amplification: Phototransistors	537
9.9 Charge Transfer Detectors.....	539
9.10 Photoemissive Detectors	546
9.11 Thermal Detectors	549
9.12 Imaging Systems	553
9.13 Photography	555
References	560

Part C Coherent and Incoherent Light Sources

10 Incoherent Light Sources

<i>Dietrich Bertram, Matthias Born, Thomas Jüstel</i>	565
10.1 Incandescent Lamps	565
10.2 Gas Discharge Lamps	566
10.3 Solid-State Light Sources	574
10.4 General Light-Source Survey	581
References	581

11 Lasers and Coherent Light Sources

<i>Orazio Svelto, Stefano Longhi, Giuseppe Della Valle, Stefan Kück, Günter Huber, Markus Pollnau, Hartmut Hillmer, Stefan Hansmann, Rainer Engelbrecht, Hans Brand, Jeffrey Kaiser, Alan B. Peterson, Ralf Malz, Steffen Steinberg, Gerd Marowsky, Uwe Brinkmann, Dennis Lo[†], Annette Borsutzky, Helen Wächter, Markus W. Sigrist, Evgeny Saldin, Evgeny Schneidmiller, Mikhail Yurkov, Katsumi Midorikawa, Joachim Hein, Roland Sauerbrey, Jürgen Helmcke</i>	583
11.1 Principles of Lasers	584
11.2 Solid-State Lasers	614
11.3 Semiconductor Lasers	695
11.4 The CO ₂ Laser	726
11.5 Ion Lasers	746
11.6 The HeNe Laser	756
11.7 Ultraviolet Lasers: Excimers, Fluorine (F ₂), Nitrogen (N ₂)	764
11.8 Dye Lasers	777
11.9 Optical Parametric Oscillators	785
11.10 Generation of Coherent Mid-Infrared Radiation by Difference-Frequency Mixing	801
11.11 Free-Electron Lasers	814
11.12 X-ray and EUV Sources	819
11.13 Generation of Ultrahigh Light Intensities and Relativistic Laser-Matter Interaction	827
11.14 Frequency Stabilization of Lasers	841
References	864

**12 Femtosecond Laser Pulses: Linear Properties, Manipulation,
Generation and Measurement**

<i>Matthias Wollenhaupt, Andreas Assion, Thomas Baumert</i>	937
12.1 Linear Properties of Ultrashort Light Pulses	938
12.2 Generation of Femtosecond Laser Pulses via Mode Locking	959
12.3 Measurement Techniques for Femtosecond Laser Pulses	962
References	979

Part D Selected Applications and Special Fields**13 Optical and Spectroscopic Techniques**

<i>Wolfgang Demtröder, Sune Svanberg</i>	987
13.1 Stationary Methods	987
13.2 Time-Resolved Methods	1012
13.3 LIDAR	1031
References	1048

14 Quantum Optics

<i>Gerard Milburn</i>	1053
14.1 Quantum Fields	1053

14.2 States of Light	1055
14.3 Measurement	1058
14.4 Dissipation and Noise	1061
14.5 Ion Traps	1066
14.6 Quantum Communication and Computation	1070
References	1077
15 Nano optics	
<i>Motoichi Ohtsu</i>	1079
15.1 Basics	1079
15.2 Nanophotonics Principles	1080
15.3 Nanophotonic Devices	1082
15.4 Nanophotonic Fabrications	1085
15.5 Extension to Related Science and Technology	1088
15.6 Summary	1088
References	1089
16 Optics far Beyond the Diffraction Limit: Stimulated Emission Depletion Microscopy	
<i>Stefan W. Hell</i>	1091
16.1 Principles of STED Microscopy	1092
16.2 Nanoscale Imaging with STED	1094
References	1097
17 Ultrafast THz Photonics and Applications	
<i>Daniel Grischkowsky</i>	1099
17.1 Guided-Wave THz Photonics	1101
17.2 Freely Propagating Wave THz Photonics	1116
References	1145
18 X-Ray Optics	
<i>Christian G. Schroer, Bruno Lengeler</i>	1153
18.1 Interaction of X-Rays with Matter	1154
18.2 X-Ray Optical Components	1156
References	1162
19 Radiation and Optics in the Atmosphere	
<i>Ulrich Platt, Klaus Pfeilsticker, Michael Vollmer</i>	1165
19.1 Radiation Transport in the Earth's Atmosphere	1166
19.2 The Radiation Transport Equation	1169
19.3 Aerosols and Clouds	1172
19.4 Radiation and Climate	1174
19.5 Applied Radiation Transport: Remote Sensing of Atmospheric Properties	1176
19.6 Optical Phenomena in the Atmosphere	1182
References	1197

20 Holography and Optical Storage	
<i>Mirco Imlau, Martin Fally, Hans Coufal[†], Geoffrey W. Burr, Glenn T. Sincerbox</i>	1205
20.1 Introduction and History	1206
20.2 Principles of Holography.....	1207
20.3 Applications of Holography.....	1217
20.4 Summary and Outlook	1222
20.5 Optical Data Storage	1223
20.6 Approaches to Increased Areal Density	1225
20.7 Volumetric Optical Recording	1227
20.8 Conclusion	1239
References	1239
 21 Laser Safety	
<i>Hans-Dieter Reidenbach</i>	1251
21.1 Historical Remarks.....	1252
21.2 Biological Interactions and Effects.....	1253
21.3 Maximum Permissible Exposure	1260
21.4 International Standards and Regulations	1267
21.5 Laser Hazard Categories and Laser Classes.....	1268
21.6 Protective Measures.....	1270
21.7 Special Recommendations	1273
References	1275
 Acknowledgements	1277
About the Authors	1279
Detailed Contents	1295
Subject Index	1313