

Contents

1	What is a Dressed Photon?	1
1.1	Comparison with Conventional Light	1
1.2	Light–Matter Interactions via Dressed Photons	4
1.3	Energy Transfer Between Nanomaterials	6
1.4	Novel Phenomena Arising from Further Coupling	7
1.5	Symbols for Quantum Operators	9
	References	9
2	Physical Picture of Dressed Photons	11
2.1	Virtual Photons Dressing Material Energy	11
2.2	Range of Interaction Mediated by Dressed Photons	18
2.2.1	Effective Interaction Between Nanomaterials	19
2.2.2	Size-Dependent Resonance and Hierarchy	33
	References	36
3	Energy Transfer and Relaxation by Dressed Photons	37
3.1	Coupled States Originating from Two Energy Levels	37
3.2	Principles of Dressed-Photon Devices	42
3.2.1	Dressed-Photon Devices Using Two Quantum Dots	43
3.2.2	Dressed-Photon Devices Using Three Quantum Dots	47
	References	56
4	Coupling Dressed Photons and Phonons	59
4.1	Novel Molecular Dissociation and the Need for a Theoretical Model	59
4.1.1	Unique Phenomena of Molecular Dissociation by Dressed Photons	59
4.1.2	Lattice Vibrations in the Probe	62
4.2	Transformation of the Hamiltonian	67
4.2.1	Diagonalization by Unitary Transformation	67
4.2.2	Physical Picture of the Quasi-Particle	71
4.2.3	The Equilibrium Positions of Atoms	73
4.3	Localization Mechanism of Dressed Photons	75
4.3.1	Conditions for Localization	75

4.3.2	Position of Localization	79
4.4	Light Absorption and Emission via Dressed-Photon–Phonons	82
References		88
5	Devices Using Dressed Photons	89
5.1	Structure and Function of Dressed-Photon Devices	89
5.1.1	Devices Utilizing Energy Dissipation	89
5.1.2	Devices in Which Coupling with Propagating Light is Controlled	115
5.2	Characteristics of Dressed-Photon Devices	117
5.2.1	Low Energy Consumption	118
5.2.2	Tamper-Resistance	125
5.2.3	Skew Resistance	126
5.2.4	Autonomy in Energy Transfer	127
References		134
6	Fabrication Using Dressed Photons	137
6.1	Molecular Dissociation by Dressed-Photon–Phonons	137
6.1.1	Comparison Between Experiments and Theories	137
6.1.2	Deposition by Molecular Dissociation	144
6.2	Lithography Using Dressed-Photon–Phonons	147
6.3	Fabrication by Autonomous Annihilation of Dressed-Photon–Phonons	160
6.3.1	Smoothing a Material Surface by Etching	160
6.3.2	Repairing Scratches on a Substrate Surface by Deposition	166
6.3.3	Other Related Methods	168
References		169
7	Energy Conversion Using Dressed-Photons	171
7.1	Conversion From Optical to Optical Energy	171
7.1.1	Multi-Step Excitation	176
7.1.2	Non-Degenerate Excitation and Applications	184
7.2	Conversion From Optical to Electrical Energy	190
7.2.1	Multi-Step Excitation and Autonomous Fabrication	191
7.2.2	Wavelength Selectivity and Light Emission	195
7.3	Conversion From Electrical to Optical Energy	200
7.3.1	Autonomous Device Fabrication	201
7.3.2	Device Operation	203
7.3.3	Applications to Other Related Devices	208
References		213

8 Spatial Features of the Dressed-Photon and its Mathematical Scientific Model	215
8.1 Hierarchy	215
8.1.1 Hierarchical Memory	216
8.1.2 Hierarchy Based on the Constituents of Nanomaterials	219
8.1.3 Hierarchy and Local Energy Dissipation	221
8.1.4 Applications Exploiting the Differences Between Propagating Light and Dressed Photons	223
8.2 Conversion From an Electric Quadrupole to an Eelectric Dipole	227
8.3 Probe-Free Methods	230
8.3.1 Magnified Transcription of the Spatial Distribution of the Interaction	230
8.3.2 Spatial Modulation of the Energy Transfer Between Quantum Dots	231
8.4 Mathematical Scientific Model	233
8.4.1 Formation of Nanomaterials	235
8.4.2 Statistical Modeling of Morphology	240
References	245
9 Summary and Future Outlook	247
9.1 Summary	247
9.2 Future Outlook	250
References	251
Appendix A: Multipolar Hamiltonian	253
Appendix B: Elementary Excitation and Exciton-Polariton	259
Appendix C: Projection Operator and Effective Interaction Operator	265
Appendix D: Transformation from Photon Base to Polariton Base	275
Appendix E: Derivation of the Equations for Size-Dependent Resonance	279
Appendix F: Energy States of a Semiconductor Quantum Dot	283

Appendix G: Solutions of the Quantum Master Equations for the Density Matrix Operators	295
Appendix H: Derivation of Equations in Chap. 4	301
Index	317