

Contents

<i>Preface</i>	ix
<i>Acknowledgements</i>	xiii
Part I Fundamentals of Raman Spectroscopy	1
1 Basic Knowledge of Raman Spectroscopy	3
1.1 Spectrum and Spectroscopy	3
1.2 Scattering and Raman Scattering	5
1.3 Fundamental Features of Raman Scattering Spectra	9
1.4 Discovery of the Raman Scattering Effects and Observation of the First Raman Spectrum	10
1.5 Historical Development of Raman Spectroscopy	13
References	16
2 Fundamental Theory of Light Scattering	19
2.1 Description of Scattering	20
2.2 Macroscopic Theory of Light Scattering	26
2.3 Microscopic Theory of Light Scattering	39
References	45
3 Experimental Foundation of Raman Spectroscopy	47
3.1 Generality of Raman Spectral Measurements	47
3.2 Experimental Apparatus	56
3.3 Main Performance Parameters of Raman Spectrometers	79
3.4 Experimental Measurements	83
3.5 Data Processing of Recorded Raman Spectra	88
3.6 A Typical Example of Vibration Raman Spectra – Raman Spectrum of CCl ₄	94
3.7 Interference Spectrometer and Fourier Transform Optics	97
References	104
4 Introduction to Modern Raman Spectroscopy I-New Raman Spectroscopic Branch Classified Based on Spectral Features	105
4.1 Non-visible Excited Raman Spectroscopy	106
4.2 Resonant Raman Spectroscopy (RRS)	106
4.3 High-Order/Multiple-Phonon Raman Spectroscopy (MPRS)	110

Contents

4.4	Raman Spectroscopy under Extreme Conditions	114
4.5	Polarized Raman Spectroscopy (PRS)	115
4.6	Time-Resolved (Transient) Raman Spectroscopy (TRRS)	116
4.7	Space-Resolved Micro-Raman Spectroscopy and Raman Microscopy	118
4.8	Surface-enhanced Raman Spectroscopy (SERS)	119
4.9	Near-Field Raman Spectroscopy (NFRS)	121
4.10	Tip-enhanced Raman Spectroscopy (TERS)	130
4.11	Non-linear and Coherent Raman Spectroscopy (NLRS)	136
4.12	Coherent Anti-Stokes Raman Scattering (CARS)	138
4.13	Stimulated Raman Scattering (SRS)	145
	References	150
5	Introduction to Modern Raman Spectroscopy II-New Raman Spectroscopic Branch Classified Based on Applied Objects	153
5.1	Common Spectroscopic Basis Related to the Study and Application of Raman Spectroscopy	153
5.2	Chemistry Raman Spectroscopy	158
5.3	Condensed Matter Raman Spectroscopy	160
5.4	Biological and Medical Raman Spectroscopy	166
5.5	Geology and Mineralogy Raman Spectroscopy	175
5.6	Art and Archeology Raman Spectroscopy	177
5.7	Industry Raman Spectroscopy	178
5.8	Raman Spectroscopy in National Security and Judicature	181
	References	182
	Part II Study of Nanostructures by Raman Spectroscopy	185
6	General Knowledge of Nanostructures	187
6.1	Nanostructure, Characteristic Length, and Dimension	187
6.2	Nanomaterials	188
6.3	Properties of Nanostructures	190
6.4	Finite Size and Specific Surface	192
6.5	The Study of Nanostructure	196
	References	197
7	Theoretical Fundamentals of Raman Scattering in Solids	199
7.1	General Knowledge of Lattice Dynamics	200
7.2	Microscopic Model of Lattice Dynamics	213
7.3	Macroscopic Model of Lattice Dynamics	222
7.4	Lattice Dynamics of Amorphous Matter	229
7.5	Raman Scattering Theories in Solids	230
	References	246

8	Theoretical Fundamentals of Raman Scattering in Nanostructures	249
8.1	Superlattices	250
8.2	Nanostructure Materials	264
8.3	Micro-Crystal Models	283
8.4	Amorphous Feature and PDOS Expression of Nanostructure Raman Spectra	296
8.5	First-Principles/ <i>ab initio</i> Calculation of Nanostructure Raman Spectra	298
	References	306
9	Routine Raman Spectra of Nanostructures	309
9.1	Characteristic Raman Spectra of Semiconductor Superlattices	310
9.2	Characteristic Raman Spectra of Nanosilicon	318
9.3	Characteristic Raman Spectra of Nanocarbons	325
9.4	Characteristic Raman Spectra of Polar Nano-Semiconductors	337
9.5	Multiple-Phonon Raman Spectra	343
9.6	Anti-Stokes Raman Spectra	352
	References	357
10	Raman Spectroscopy of Nanostructures with Exciting Laser Features	361
10.1	Raman Spectra with Changing of Exciting Light Wavelengths – Resonant Raman Spectra	361
10.2	Raman Spectra with Exciting Laser Polarization	373
10.3	Raman Spectra with Exciting Laser Intensity	378
	References	392
11	Raman Spectra with Samples of Nanostructures	395
11.1	Effects of Sample Sizes on Raman Spectra of Nanostructures	395
11.2	Effects of Sample Shapes on Raman Spectra in Nanostructures	409
11.3	Effects of Sample Component and Micro-structure on Raman Spectra in Nanostructures	413
	References	417
12	Electron-Phonon Interactions in Raman Spectroscopy of Nanostructures	419
12.1	Abnormal Raman Spectral Features in Nanostructures	419
12.2	Origin of No FSE on Phonons	420
12.3	Fröhlich Interaction in Nanostructures	423
12.4	Theoretical Raman Spectra of Non-polar and Polar Nano-Semiconductors	424
12.5	Amorphous Feature of Nanocrystal Raman Spectra of No FSE on Phonons and the Breaking of Translation Symmetry in Nano-Semiconductors	426
	References	428

Appendices	429
Appendix I Electromagnetic Waves and Lasers	429
1.1 Electromagnetic Wavelength	429
1.2 Laser Types	430
1.3 Laser Lines and Ionic/Atomic Lines of Gas Lasers used Commonly in Raman Spectroscopy	432
Appendix II Standard Spectral Lines	438
II.1 Spectral Lines of Mercury Lamp in Visible Range	438
II.2 Standard Lines of Neon Spectral Lamp	439
Appendix III Raman Tensors	442
III.1 Raman Tensors and Symmetric Attributes	442
III.2 Applications of Raman Tensors	447
Appendix IV Constitution, Polarity, and Symmetry Structure of Crystals	452
IV.1 Constitution, Polarity, and Crystal Structure of Crystals	452
IV.2 Syngony and its Basic Vector, Bravais Lattice, and Point Group Symmetry	455
Appendix V Brillouin Zones, Vibration Modes, and Raman Spectra of Typical Ordinary and Semiconducting Crystals	458
V.1 Brillouin Zones and Symmetrical Points of Cubic System	458
V.2 Vibrational Modes and their Symmetries of Several Crystals	460
V.3 Structures, Symmetries, and Raman Spectra of Several Semiconducting Crystals	461
Appendix VI Physical Parameters, Constants, and Units	466
VI.1 Periodic Table of the Elements	466
VI.2 Electronic Structure of Atoms	467
VI.3 Common Physical Constant and the Performance Parameters of Optical Glass	470
References	472
<i>Index</i>	473