

# Contents

<b>1. Introduction.</b> By M. Cardona and G. Güntherodt . . . . .	1
1.1 Survey of 1975 Volume . . . . .	1
1.2 Contents of the Present Volume. . . . .	2
1.3 Contents of the Following Volume . . . . .	4
1.4 Contents of the Forthcoming Volume . . . . .	5
1.5 Recent Topics and Highlights of Light Scattering in Solids . . . . .	5
1.5.1 Instrumentation, Techniques . . . . .	6
1.5.2 Semiconductors . . . . .	8
1.5.3 Semiconductor Surfaces . . . . .	9
1.5.4 Semiconductor Superlattices . . . . .	10
1.5.5 Amorphous Semiconductors, Laser Annealing . . . . .	10
1.5.6 Brillouin Scattering from Opaque Materials. . . . .	11
1.5.7 Layer Materials. . . . .	11
1.5.8 Superconductors . . . . .	12
1.5.9 Spin-Dependent Effects . . . . .	13
1.5.10 Surface-Enhanced Raman Scattering. . . . .	14
1.5.11 Miscellaneous . . . . .	14
References . . . . .	15
<b>2. Resonance Phenomena.</b> By M. Cardona (With 60 Figures) . . . . .	19
2.1 Classical Theory: Elastic Scattering by Molecules, Liquids, and Solids . . . . .	22
2.1.1 Scattering Cross Section: Thompson Scattering . . . . .	22
2.1.2 Depolarized Scattering. . . . .	24
2.1.3 Elastic Scattering in Solids . . . . .	26
2.1.4 Inelastic Scattering by Molecules . . . . .	29
2.1.5 Resonant First-Order Raman Scattering . . . . .	33
2.1.6 Resonant Second-Order Raman Scattering . . . . .	35
2.1.7 Absolute Raman Scattering Cross Sections for Molecules . . . . .	37
2.1.8 First-Order Raman Scattering in Crystals . . . . .	38
2.1.9 The Raman Tensor . . . . .	45
2.1.10 Factor Group Analysis of Phonon Symmetries . . . . .	50
2.1.11 Fluctuation-Dissipation Analysis . . . . .	56
2.1.12 Scattering by Longitudinal Ir-Active Phonons: Faust-Henry-Coefficient . . . . .	58
2.1.13 Second-Order Raman Scattering in Crystals . . . . .	62

2.1.14	Brillouin Scattering . . . . .	69
2.1.15	Light Scattering in Amorphous and Disordered Materials . . . . .	76
2.1.16	Defect-Induced Raman Spectra in Crystalline Materials . . . . .	85
2.1.17	Stimulated Raman Scattering and Third-Order Susceptibilities . . . . .	87
2.1.18	Absolute Scattering Cross Sections . . . . .	92
	a) General Principles . . . . .	92
	b) Relative Methods for Determining Scattering Efficiencies: Sample Substitution . . . . .	95
	c) Brillouin-Raman Efficiency Comparison. . . . .	96
	d) Stimulated Raman Scattering . . . . .	96
	e) Electric-Field-Induced Infrared Absorption . . . . .	97
	f) LO/TO Intensity Ratio in Zincblende . . . . .	97
	g) Sign of the Raman Polarizability . . . . .	98
2.2	Quantum Theory . . . . .	99
2.2.1	Hamiltonian for Molecules and Solids in Interaction with an Electromagnetic Field. . . . .	99
2.2.2	Electronic Raman Scattering . . . . .	102
2.2.3	Scattering by Phonons: Frank-Condon Formulation . . . . .	105
2.2.4	Perturbation Theory for Electron-Phonon Interaction: First-Order Raman Effect . . . . .	110
	a) Parabolic Bands . . . . .	112
2.2.5	Review of the Optical Properties of Tetrahedral Semiconductors. . . . .	117
2.2.6	Contributions to the Raman Tensor for First Order Scattering by Phonons. . . . .	120
	a) $E_0, E_0 + \Delta_0$ -Edge . . . . .	121
	b) $E_1 - E_1 + \Delta_1$ -Edge . . . . .	124
	c) $E_2$ Edge . . . . .	126
	d) $E'_0$ Edge of Diamond . . . . .	126
2.2.7	Fluorite-Type Materials: $\text{CaF}_2$ , $\text{SrF}_2$ , and $\text{BaF}_2$ . . . . .	127
2.2.8	Forbidden LO-Scattering. . . . .	128
	a) Heuristic Approach. . . . .	130
	b) 3- $d$ Critical Points ( $E_0, E_0 + \Delta_0$ Edges) . . . . .	132
	c) 2- $d$ Critical Points ( $E_1, E_1 + \Delta_1$ ) Edges . . . . .	133
	d) Electric-Field-Induced Effect. . . . .	134
2.2.9	Resonant Raman Scattering: Effect of Exciton Interaction	135
2.2.10	Second-Order Raman Scattering by Two Phonons. . . . .	138
2.2.11	Multiphonon Scattering . . . . .	145
2.2.12	Brillouin Scattering . . . . .	150
2.3	Resonant Scattering by Phonons: Experimental Results . . . . .	151
2.3.1	First-Order Raman Scattering in Germanium-Zincblende: $E_0, E_0 + \Delta_0$ Gaps . . . . .	152
	a) Allowed Scattering by Phonons . . . . .	152
	b) Forbidden Scattering by Phonons . . . . .	155

2.3.2	First-Order Raman Scattering in Germanium-Zincblende:	
	$E_1, E_1 + \Delta_1$ Gaps . . . . .	155
	a) Allowed Scattering . . . . .	155
	b) Forbidden LO-Scattering . . . . .	158
2.3.3	Second-Order Raman Scattering in Germanium-Zincblende	158
	a) $E_0, E_0 + \Delta_0$ Gaps . . . . .	160
	b) $E_1, E_1 + \Delta_0$ Gaps . . . . .	162
2.3.4	Elasto-Optic Constants . . . . .	163
2.3.5	Multiphonon Scattering . . . . .	167
2.3.6	Cuprous Oxide ( $\text{Cu}_2\text{O}$ ) . . . . .	168
	a) First-Order Raman Spectrum . . . . .	169
	b) Higher-Order Raman Spectrum . . . . .	170
2.3.7	AgCl, AgBr . . . . .	172
	References . . . . .	173

**3. Optical Multichannel Detection**

	By R. K. Chang and M. B. Long (With 9 Figures) . . . . .	179
3.1	Image Intensifiers and Detectors . . . . .	180
	3.1.1 Microchannel Plate (MCP) Image Intensifiers . . . . .	180
	3.1.2 Single-Stage Electrostatic Intensifiers . . . . .	181
	3.1.3 Secondary Electron Conduction (SEC) Cameras . . . . .	182
	3.1.4 Silicon Intensified Target (SIT) Detectors . . . . .	183
	3.1.5 Intensified Silicon Intensified Target (ISIT) Detectors . . . . .	187
	3.1.6 Intensified Silicon Photodiode (ISPD) Array Detectors . . . . .	188
3.2	Multistage Spectrographs . . . . .	192
3.3	Computer Control . . . . .	194
	3.3.1 Computer System Selection . . . . .	195
	3.3.2 Data Analysis and Accumulation . . . . .	196
3.4	Selected Applications . . . . .	197
	3.4.1 Spatial Resolution . . . . .	198
	3.4.2 Temporal Evolution . . . . .	199
	3.4.3 Pulsed Spectroscopy . . . . .	200
3.5	Conclusions . . . . .	202
3.6	Glossary . . . . .	202
	References . . . . .	204

**4. Coherent and Hyper-Raman Techniques.** By H. Vogt (With 19 Figures)

4.1	Basic Principles . . . . .	208
	4.1.1 Elementary Description of Coherent and Hyper-Raman Effects . . . . .	208
	4.1.2 Definition and General Structure of the Nonlinear Susceptibilities . . . . .	211
	4.1.3 Raman Resonances in $\chi^{(3)}$ and $\chi^{(5)}$ . . . . .	215
	a) SRS . . . . .	216
	b) CARS . . . . .	219

c) Rikes . . . . .	220
d) HRS . . . . .	221
4.2 Coherent Antistokes Raman Spectroscopy (CARS) . . . . .	223
4.2.1 Line Shapes . . . . .	223
4.2.2 Experimental Problems . . . . .	226
4.2.3 CARS Spectra of Solids . . . . .	229
a) Early Work . . . . .	229
b) Centrosymmetric Crystals . . . . .	229
c) Noncentrosymmetric Crystals . . . . .	230
d) D4WM . . . . .	230
4.3 Raman-Induced Kerr Effect Spectroscopy (RIKES) and Related Techniques . . . . .	231
4.4 Double Resonances Interferences in Four-Wave Mixing . . . . .	232
4.5 Hyper-Raman Spectroscopy (HRS) . . . . .	236
4.5.1 Selection Rules . . . . .	236
4.5.2 Experimental Problems . . . . .	237
4.5.3 Spontaneous HRS of Phonons and Polaritons . . . . .	238
4.5.4 Resonant and Stimulated HRS . . . . .	241
References . . . . .	241
<b>Subject Index . . . . .</b>	<b>245</b>