## Modern Raman Spectroscopy – A Practical Approach

**Ewen Smith** Strathclyde University, Glasgow

Geoffrey Dent Intertek ASG and UMIST, Manchester



## Contents

Preface	•		ix	
Acknowledgements				
CHAPTER 1 INTRODUCTION BASIC THEORY				
		AND PRINCIPLES	1	
1.1	Introdu	iction	1	
1.2	Basic Theory			
1.3	Molecular Vibrations			
1.4	Summary			
CHAPTER 2 THE RAMAN EXPERIMENT – RAMAN		THE RAMAN EXPERIMENT – RAMAN		
		INSTRUMENTATION, SAMPLE PRESENTATION,		
		DATA HANDLING AND PRACTICAL ASPECTS		
		OF INTERPRETATION	23	
2.1	Introduction		23	
2.2	Choice of Instrument		24	
2.3	Visible Excitation		24	
2.4	NIR Excitation			
2.5	Raman Sample Preparation and Handling			
2.6	Sample Mounting Accessories			
2.7	Microscopy			
2.8	Calibra	ition	51	
2.9	Data Handling, Manipulation and Quantitation		53	
2.10	Approach to Qualitative Interpretation		61	
2.11	Summa	ıry	67	
CHAP	TER 3	THE THEORY OF RAMAN SPECTROSCOPY	71	
3.1	Introduction		71	
3.2	Absorption and Scattering			
3.3	States of a System and Hooke's Law			
3.4	The Na	ature of Polarizability and the Measurement		
	of Pola	rization	76	

Coments
---------

3.5	The Basic Selection Rule	80		
3.6	Number and Symmetry of Vibrations			
3.7	Symmetry Elements and Point Groups			
3.8	The Mutual Exclusion Rule			
3.9	The Kramer Heisenberg Dirac Expression			
3.10	Lattice Modes	90		
3.11	Conclusions	91		
CHAP	TER 4 RESONANCE RAMAN SCATTERING	93		
4.1	Introduction			
4.2	Theoretical Aspects			
4.3	Practical Aspects			
4.4	Examples of the Use of Resonance Raman Scattering			
4.5	Conclusions	112		
CHAPTER 5 SURFACE-ENHANCED RAMAN SCATTERING				
	AND SURFACE-ENHANCED RESONANCE			
	RAMAN SCATTERING	113		
5.1	Introduction	113		
5.2	Theory	116		
5.3	Electromagnetic and Charge Transfer Enhancement			
5.4	Selection Rules			
5.5	Applications of SERS			
5.6	Applications of SERRS			
5.7	The Basic Method	127		
CHAP	TER 6 APPLICATIONS	135		
6.1	Introduction	135		
6.2	Inorganics and Minerals	135		
6.3	Art and Archaeology	143		
6.4	Polymers and Emulsions	143		
6.5	Colour	149		
6.6	Electronics Applications	158		
6.7	Biological and Pharmaceutical Applications			
6.8	Forensic Applications	166		
6.9	Plant Control and Reaction Following	167		
6.10	Summary	172		
CHAF	TER 7 MORE ADVANCED RAMAN SCATTERING			
	TECHNIQUES	181		
7.1	Flexible Optics	182		
7.2	Tuneable Lasers, Frequency Doubling and Pulsed Lasers			
7.3	Spatially Resolved Systems	189		

vi

Contents	vii
7.4 Nonlinear Raman Spectroscopy	191
7.5 Time Resolved Scattering	196
7.6 Raman Optical Activity	198
7.7 UV Excitation	199
7.8 Conclusions	201
Index	203