
Contents

1	An Introduction to Chalcogenide Glasses	1
1.1	Introduction	1
1.2	Structure of Chalcogenide Glasses	1
1.3	Electronic Properties of Chalcogenide Glasses	6
1.3.1	Electronic States in Chalcogenide Glasses	6
1.3.2	Measurements of the Absorption Coefficient and the Optical Gap	8
1.4	Chalcogenide Glasses for Near-Infrared Optics	10
1.5	Chalcogenide Glasses for Mid-IR and Far-IR Applications	12
1.6	Bulk Chalcogenide Glasses, Composition, and Optical Constants	14
1.7	Chalcogenide Thin Films and Comparison with the Bulk	17
1.8	Photoinduced Changes in Chalcogenide Glasses	21
1.8.1	Photoinduced Phenomena	21
1.8.2	Exposure Characteristics	23
1.8.3	Measurements of the Propagation Losses by a Prism Coupler	25
1.8.4	Measurements of Propagation Losses in Laser-Written Waveguides	26
1.9	Summary	27
2	Basic Concepts of Nonlinear Optics	29
2.1	Polarization	29
2.2	Wave Equation	30
2.2.1	Linear Optics	31
2.2.2	Nonlinear Optics	34
2.3	The Harmonic Oscillator Model in Linear Optics	37
2.4	The Anharmonic Oscillator Model in Nonlinear Optics	40
2.5	Properties of Anisotropic Media	42
2.6	Second-Harmonic Generation	43

2.7	Self-Phase Modulation and Soliton Generation	44
2.7.1	Optical Solitons	45
2.7.2	Mechanisms of Nonlinearity	47
2.7.3	Optical Phase Conjugation	48
2.7.4	Optical Bistability	50
2.7.5	Stimulated Raman Scattering	51
2.7.6	Third-Harmonic Generation	52
3	Experimental Techniques to Measure Nonlinear Optical Constants	55
3.1	Introduction	55
3.2	Degenerate Four-Wave Mixing	55
3.3	Nearly Degenerate Three-wave Mixing	59
3.4	Z-Scan	61
3.5	Third-Harmonic Generation	63
3.6	Optical Kerr Gate and Ellipse Rotation	64
3.6.1	Optical Kerr Gate	64
3.6.2	Ellipse Rotation	66
3.7	Self-Phase Modulation	67
3.8	Spectrally Resolved Two-Beam Coupling	69
3.9	Mach-Zehnder Interferometry	70
3.10	Summary	73
4	Measurement of Nonlinear Optical Constants	75
4.1	Measurements of Nonlinear Refractive Index n_2	75
4.2	Measurements of Nonlinear Absorption Coefficient β	91
4.3	Determination of Three Photon-Absorption and Multiphoton Absorption	94
4.4	Second-Harmonic Generation, Phase Conjugation, etc	95
4.5	Comparison of Chalcogenide Nonlinearities with Silica	102
5	Optical Nonlinearities in Chalcogenide Fibres	107
5.1	Fabrication of Chalcogenide Fibers and Their Linear Optical Properties	107
5.1.1	Fabrication of Fibers by Extrusion	108
5.1.2	Physical and Linear Optical Properties of Chalcogenide Fibers	109
5.2	Nonlinear Optical Properties of Fibers	111
5.2.1	Features of Chalcogenide Glass as a Nonlinear Material	111
5.2.2	Stimulated Light Scattering and Super-Continuum Generation	112
5.2.3	Second-Order Nonlinearity in Poled Glass	113

5.3	Pulse Propagation in Fibers	114
5.3.1	Propagation of Optical Fields	114
5.3.2	Nonlinear Pulse Propagation	116
5.3.3	Higher-Order Nonlinear Effects	120
5.4	Group-Velocity Dispersion Compensation by Fiber Gratings ..	121
5.5	Applications	122
6	Optical Switching in Chalcogenide Glasses	129
6.1	Criteria of Material Properties for All-optical Switching	129
6.2	Design Issues for All-Optical Switching	131
6.3	All-Optical Switching in Chalcogenide Glasses	131
6.3.1	All-Optical Switching using Chalcogenide Glass Fibers.....	131
6.3.2	All-Optical Switching in Thin Chalcogenide Films ...	137
6.4	All-Optical Switches, AND Gate, NOR Gate, etc.	145
6.4.1	Introduction	145
6.4.2	Nonlinear Interferometric Devices	147
6.4.3	Nonlinear Beam-Coupling Devices	147
6.4.4	Polarization Switching Devices	148
6.4.5	Soliton Switching Devices	148
6.5	Limitations of All-Optical Switches	149
6.6	Summary	149
7	Issues and Future Directions	151
7.1	Optical Limiting	151
7.2	Second-Harmonic Generation and Electro-Optic Effects	153
7.3	Fabrication of Rib and Ridge Waveguides and of Fiber Gratings	155
7.4	All-Optical Nonlinear Integrated Circuits	166
7.5	Inclusion of Metal Nanoparticles to Enhance Nonlinearity ...	168
7.6	Other Applications	169
7.7	Summary	175
	References	177
	Index	195