

Contents

Preface	v
Acknowledgement	ix
1 Introduction	1
2 Disorder and glass transition	7
2.1 Definition of disorder	7
2.2 Glass transition	9
2.3 Glass formation	14
3 Preparation	23
3.1 Rapid quenching from the liquid phase	23
3.2 Rapid condensation from the gas phase	24
3.2.1 Physical vapour deposition	24
3.2.2 Chemical vapour deposition	25
4 Structure	29
4.1 Diffraction pattern	30
4.2 Models for the amorphous structure	33
4.2.1 Tetrahedrally bonded semiconductors: a-Si and a-Ge	33
4.2.2 Chalcogenide glasses	37
4.3 Medium-range order of small-angle X-ray scattering	39
4.4 Computer simulation	42
4.4.1 Monte Carlo method	43

4.4.2	Molecular-dynamics method	45
5	Electronic states	51
5.1	Nature of conduction and valence bands and tail states	51
5.2	Anderson localization	60
6	Gap states and defects	67
6.1	Gap states	67
6.2	Measurements of defects	68
6.3	Dangling bonds in a-Si and a-Si:H	84
6.4	Defects in chalcogenide glasses	92
7	Transport	99
7.1	Electrical conduction near the mobility edge	99
7.2	The scaling theory of Anderson localization	102
7.3	Conductivity taking into account multiple scattering – deviation of conductivity from the Boltzmann conductivity	105
7.4	Transition from localization to delocalization and conductivity	108
7.5	Band conduction	109
7.6	Hopping conduction	114
7.6.1	Nearest-neighbor hopping	114
7.6.2	Variable-range hopping	115
7.7	AC conduction	119
7.8	Hall effect	123
7.9	Thermoelectric power	125
7.10	Relationship between the electrical conductivity and the thermoelectric power	126
7.11	Electron-phonon interaction and electrical conduction	129
7.12	Dispersive transport	130
8	Optical properties	137
8.1	Optical absorption	137
8.1.1	Band to band transition and absorption edge	138
8.1.2	High energy absorption	141
8.1.3	Tail absorption	142

8.1.4	Theoretical approach to the exponential tail	149
8.2	Photoluminescence	153
8.2.1	Intratransition within the localized centre .	153
8.2.2	Photoluminescence due to radiative recombination between electrons and holes	158
8.2.3	Photoluminescence due to radiative recombination of excitons	170
9	Recombination	173
9.1	Geminate pair recombination	173
9.2	Nongeminate pair recombination	174
9.3	Nonradiative recombination	175
9.4	Exciton recombination	178
9.5	Optically detected magnetic resonance (ODMR) .	179
9.6	Photoconductivity	191
9.6.1	Photoconduction	191
9.6.2	Basic processes in photoconduction	193
9.6.3	Temperature dependence of photoconductivity	203
9.6.4	Spin-dependent photoconductivity	210
10	Electron-phonon interaction and self-trapping of carriers	217
10.1	Self-trapping of carriers	217
10.2	Self-trapping of holes in a-SiO ₂ and a-Si:H	220
10.3	Small polarons	227
11	Light-induced phenomena	231
11.1	a-Si:H	231
11.1.1	General aspects of light-induced phenomena in a-Si:H	231
11.1.2	Mechanisms for the light-induced defect creation in a-Si:H	235
11.1.3	Annealing processes of the light-induced defects	247
11.1.4	Light-induced structural change	254
11.2	Chalcogenide glasses	255

11.2.1	General aspects	255
11.2.2	Photodarkening and photostructural change	256
11.2.3	Light-induced metastable defects	259
11.2.4	Light-induced phenomena and amorphous structures	266
12	Thermal equilibrium processes and defect formation mechanisms	269
12.1	Thermal equilibrium processes	269
12.2	Defect formation mechanisms	278
12.3	Relaxation processes for annealing of dangling bonds	288
13	Artificial materials	295
13.1	Introduction	295
13.2	Energy levels in the superlattices and band-edge modulated multilayers	298
13.2.1	Superlattices	298
13.2.2	Band-edge modulated multilayers	300
13.3	Basic properties of the superlattices and the band- edge modulated multilayers	301
13.3.1	Superlattices	301
13.3.2	Band-edge modulated multilayers	310
14	Summary of specific materials	317
14.1	a-Si:H and related materials	317
14.1.1	Hydrogen-related properties	317
14.1.2	General aspects of recombination processes and gap states in a-Si:H	326
14.1.3	Doping	354
14.1.4	Alloys	361
14.2	Chalcogenide glasses	367
14.2.1	General features	367
14.2.2	Electronic properties	368
	References	383
	Index	411