

Contents

1. Introduction	1
1.1 Experimental Aspects	2
1.2 Outline	3
2. Absorption of Laser Light	5
2.1 Fundamental Optical Properties	5
2.1.1 Plane-Wave Propagation	5
2.1.2 Macroscopic Material Properties	8
2.1.3 Nonmetals	9
2.1.4 Metals	12
2.2 Modified Optical Properties	15
2.2.1 Self-Focusing	16
2.2.2 Phenomena Due to Free-Carrier Generation	20
2.2.3 Semiconductors	21
2.2.4 Insulators	27
2.2.5 Reflection by Hot Metals	31
2.3 Phase Transitions and Shape Effects	32
2.3.1 Surface Corrugation	32
2.3.2 Shaping Surfaces	35
2.3.3 Hole Drilling	38
2.3.4 Evaporation and Plasma Effects	39
3. Heating by Laser Light	41
3.1 Temperature Distributions	41
3.1.1 Thermalization and Heat Transport	41
3.1.2 Solution of the Heat-Flow Equation	44
3.1.3 Cooling	47
3.1.4 Moving Sources	48
3.1.5 Variable Parameters	50
3.1.6 Impact of Absorption Phenomena on Temperature	52
3.2 Heat-Treatment Processes	55
3.2.1 Annealing with Laser Beams	55
3.2.2 Thermal Stress	57
3.2.3 Crystallization of Amorphous Semiconductor Layers	58
3.2.4 Compound Synthesis	62
3.2.5 Transformation Hardening	65

4. Melting and Solidification	68
4.1 Fundamentals	69
4.1.1 Regimes of Laser Remelting	69
4.1.2 Heat Flow and Latent Heat	72
4.1.3 Thermodynamics	76
4.1.4 Interface Kinetics	81
4.1.5 Nucleation	83
4.2 Regrowth of Ion-Implanted Substrates	85
4.2.1 Semiconductor Substrates	85
4.2.2 Segregation and Trapping	89
4.2.3 Metallic Substrates	93
4.3 Surface Alloying	96
4.3.1 Semiconductor Substrates	97
4.3.2 Constitutional Supercooling	98
4.3.3 Metallic Substrates	104
4.4 Melt Quenching	107
4.4.1 Glass Formation	107
4.4.2 Silicon-Based Systems	113
4.4.3 Metal-Based Systems	114
5. Evaporation and Plasma Formation	115
5.1 Fundamentals	116
5.1.1 The Thermodynamics and Kinetics of Evaporation	116
5.1.2 Hydrodynamics	121
5.1.3 Ionization of the Vapor	122
5.1.4 Gas Breakdown	123
5.2 Evaporation at Moderate Irradiance Levels	125
5.2.1 Beam Heating and Evaporation	125
5.2.2 Vapor Expansion and Recoil	128
5.2.3 Drilling, Welding, Cutting	131
Hole Drilling	131
Penetration Welding	134
Cutting	137
5.3 Absorption Waves	137
5.3.1 Laser-Supported Combustion Waves	138
5.3.2 Plasma-Enhanced Coupling	142
5.3.3 Laser-Supported Detonation Waves	146
5.3.4 Effects of LSDWs on the Beam-Material Interaction	148
5.4 Phenomena at Very High Irradiance	150
5.4.1 The Self-Regulating Plasma	152
5.4.2 Laser-Driven Deflagration Wave	156
5.4.3 Inertial Confinement	157

5.5 Pulsed Laser Deposition	159
5.5.1 Solid Film Growth from a Vapor	160
5.5.2 The PLD Process	162
A. Appendix	166
A.1 Selected Material Data	166
A.2 Green's Functions for Solving the Heat-Flow Equation	168
A.3 Numerical Solution of the Heat-Flow Equation	173
A.4 Units and Symbols	174
A.4.1 Constants	175
A.4.2 Variables	175
A.4.3 Subscripts	177
References	179
Subject Index	193