

Table of contents

Introduction	11
1. Laser ablation and laser-induced surface instability	14
1.1. General aspects of pulsed laser ablation	14
1.2. Electronic excitation	15
1.2.1. Nonlinear absorption/ionization in <i>dielectrics</i>	15
1.2.2. Absorption of laser irradiation in <i>silicon</i>	19
1.2.3. Absorption of laser energy in <i>metals</i>	20
1.2.4. Ultrafast excitation/nonequilibrium	22
1.3. Transient effects of multipulse laser irradiation	27
1.3.1. Laser induced defects	28
1.3.2. Incubation	28
1.3.3. Conclusion	30
1.4. Models of ultrashort pulsed laser ablation	30
1.4.1. Coulomb explosion in Dielectrics	31
1.4.2. Ablation mechanisms of Semiconductors and Metals	32
1.5. Conclusion	36
2. LIPSS: survey of experimental data and models	37
2.1. Experimental observation of LIPSS	37
2.1.1. Femtosecond laser-induced surface structures	37
2.2. Modeling of ripples formation	39
2.2.1. Inhomogeneous energy deposition as origin of LIPSS	40
2.2.2. "Extension" of the classical approach	43
2.2.3. Drawback of the classical theory	45
2.3. Self-organization as origin of LIPSS	46
2.3.1. Patterns originating from instability	47
2.3.2. Ultrashort pulsed laser induced surface instability	48
2.4. Conclusion	51
3. Laser polarization in the model of self-organization	52
3.1. Pattern formation upon ion-beam sputtering (review)	52
3.2. Model	54
3.2.1. The role of anisotropic excitation	56
3.2.2. Evolution of the surface profile	57
3.2.3. Linear stability analysis	60
3.2.4. Morphological diagram for the ripple orientation	62
3.2.5. Nonlinear regime	64
3.3. Numerical results and discussion	65
3.3.1. Influence of polarization	66
3.3.2. Period of numerically calculated pattern	67
3.3.3. Consideration of a positive feedback in the model	69
3.3.4. Time evolution	69
3.4. Conclusion	70
4. Instrumentation	71
4.1. Laser system	71
4.2. Gaussian beam	73
4.3. Experimental setup	75

4.4.	Sample analysis	76
4.4.1.	Atomic Force Microscope Solver P47H	76
4.4.2.	Scanning Electron Microscope (Zeiss EVO 40)	79
5.	Control parameters in pattern formation process.....	81
5.1.	Laser polarization as control parameter.....	81
5.1.1.	Ripples induced by elliptically polarized laser beam.....	82
5.2.	Surface defects.....	91
5.3.	Irradiation-dose dependence.....	94
5.3.1.	Dependence on the local intensity of laser beam	94
5.3.2.	Single and multipulse irradiation	95
5.4.	Multipulse feedback effect	98
5.4.1.	Effect of irradiation dose.....	99
5.4.2.	Effect of pulse separation	102
5.4.3.	Numerical calculations	104
5.5.	Peculiarities of nanostructures on metallic targets	107
5.6.	Conclusion	110
6.	Impact of nanostructure formation on material properties	112
6.1.	Electrical properties of nanostructures	112
6.2.	Raman spectroscopic analysis	115
6.3.	Cross-sectional analysis.....	118
6.3.1.	Technique	119
6.3.2.	Results	120
6.4.	Photoluminescence measurements	122
6.5.	Conclusion	124
7.	General Conclusions and Outlook	125
8.	Appendix	128
9.	Acknowledgements	129
10.	References	130