

Contents

Preface XI

List of Contributors XV

- 1 Introduction** 1
Motoichi Ohtsu
- 1.1 History 1
- 1.2 Fiber Probes and Sensing Systems 2
- 1.3 Theory 3
- 1.4 Devices 6
- 1.5 Fabrications 9
- 1.6 Applications to Systems and Evolution to Related Sciences 11
- 1.7 Toward the Future 12
- References 13
- 2 Nanofabrication Principles and Practice** 17
Tadashi Kawazoe and Motoichi Ohtsu
- 2.1 Adiabatic Nanofabrication 17
- 2.2 Nonadiabatic Nanofabrication 19
- 2.2.1 Nonadiabatic Near-Field Optical Chemical Vapor Deposition 19
- 2.2.2 Nonadiabatic Near-Field Photolithography 27
- References 33
- 3 Nanofabrications by Self-Organization and Other Related Technologies** 35
Takashi Yatsui, Wataru Nomura, Kazuya Hirata, Yoshinori Tabata, and Motoichi Ohtsu
- 3.1 Introduction 35
- 3.2 Near-Field Optical Chemical Vapor Deposition 35
- 3.3 Self-Assembling Method Via Optical Near-Field Interactions 41
- 3.3.1 Regulating the Size and Position of Nanoparticles Using Size-Dependent Resonance 41

3.3.2	Self-Assembly of Nanoparticles Using Near-Field Desorption	45
3.3.3	One-Dimensional Alignment of Nanoparticles Using an Optical Near-field	49
3.4	Near-Field Imprint Lithography	55
3.5	Nonadiabatic Optical Near-Field Etching	60
	References	64
4	Fabrication of Quantum Dots for Nanophotonic Devices	69
	<i>Kouichi Akahane and Naokatsu Yamamoto</i>	
4.1	Introduction	69
4.2	Fabrication of Self-Assembled QDs	71
4.2.1	Control of Density and Emission Wavelength of Self-Assembled QDs	73
4.2.2	Shortening Emission Wavelengths of Self-Assembled QDs	73
4.2.3	Controlling the Density of Self-Assembled QDs	77
4.2.4	Fabrication of Self-Assembled QDs with Antimonide-Related Materials	80
4.2.5	Fabrication of Ultrahigh-Density QDs	83
4.2.6	Summary	90
4.3	Fabrication Techniques of Site-Controlled Nanostructures	91
4.3.1	Nanopositioning Technique for Quantum Structures with Dioxide Mask	91
4.3.2	Artificially Prepared Nanoholes for Arrayed QD Structure Fabrication	95
4.3.3	Nanojet Probe Method for Site-Controlled InAs QD Structure	96
4.3.4	Scanning Tunneling Probe Assisted Nanolithography for Site-Controlled Individual InAs QD Structure	98
4.3.5	Metal-Mask MBE Technique for Selective-Area QD Growth	99
4.4	Silicon-Related Quantum Structure Fabrication Technology	100
4.4.1	III-V Compound Semiconductor QD on a Si Substrate	100
4.4.2	Fabrication Technique of Silicon Nanoparticles as Si-QD Structures	101
	References	103
5	ZnO Nanorod Heterostructures for Nanophotonic Device Applications	105
	<i>Gyu-Chul Yi</i>	
5.1	Introduction	105
5.2	ZnO Axial Nanorod Quantum Structures	108
5.3	ZnO Radial Nanorod Heterostructures	117
5.4	Conclusions	126
	References	128

6	Lithography by Nanophotonics	131
	<i>Ryo Kuroda, Yasuhisa Inao, Shinji Nakazato, Toshiki Ito, Takako Yamaguchi, Tomohiro Yamada, Akira Terao, and Natsuhiko Mizutani</i>	
6.1	Introduction	131
6.2	Principle of the Optical Near-Field Lithography	132
6.3	Optical Near-Field Lithography System	136
6.4	Fabricated Patterns by Optical Near-Field Lithography	140
6.5	Improvement of Resolution and Fabricated Ultrafine Patterns	142
6.6	Summary	144
	References	146
7	Nanopatterned Media for High-Density Storage	147
	<i>Hiroyuki Hieda</i>	
7.1	Introduction	147
7.2	Nanopatterned Media	149
7.2.1	Fabrication Process of Nanopatterned Media	150
7.3	Block-Copolymer Lithography for Nanopatterned Media	153
7.3.1	Self-Assembled Phase Separation of Block-Copolymers	153
7.3.2	Fabrication of Magnetic Nanodots by Block-Copolymer Lithography	155
7.4	Control of Orientation of Self-Assembled Periodic Patterns of Block-Copolymers	158
7.5	Summary	162
	References	164
8	Nanophotonics Recording Device for High-Density Storage	167
	<i>Tetsuya Nishida, Takuya Matsumoto, and Fumiko Akagi</i>	
8.1	Introduction	167
8.2	Thermally Assisted Magnetic Recording Simulation	168
8.3	The ‘Nanobeak,’ a Near-Field Optical Probe	170
8.4	Bit-Patterned Medium with Magnetic Nanodots	172
8.5	Hybrid Recording Experiment	174
8.6	Near-Field Optical Efficiency in Hybrid Recording	175
8.7	Summary	177
	References	178
9	X-ray Devices and the Possibility of Applying Nanophotonics	179
	<i>Masato Koike, Shinji Miyauchi, Kazuo Sano, and Takashi Imazono</i>	
9.1	Introduction	179
9.2	Design of the Multilayer Lamellar-Type Grating	180
9.3	Specification of the Multilayer Lamellar-Type Grating	183
9.4	Fabrication of Multilayer Lamellar-Type Gratings	183
9.5	Simulation of Diffraction Efficiency	185
9.6	Measurement of Diffraction Efficiency	186
9.7	Roughness Evaluation using Debye–Waller Factors	189
	References	190

10	Nanostructuring of Thin-Film Surfaces in Femtosecond Laser Ablation	193
	<i>Kenzo Miyazaki</i>	
10.1	Introduction	193
10.2	Experimental	194
10.3	Properties of Nanostructuring	194
10.3.1	Polarization	195
10.3.2	Multiple Pulses	195
10.3.3	Fluence	195
10.3.4	Laser Wavelength	197
10.3.5	Pulse Width	197
10.4	Bonding-Structure Change	197
10.5	Dynamic Processes	198
10.5.1	Reflectivity of Ablating Surface	199
10.5.2	Ultrafast Dynamics	202
10.6	Local Fields	204
10.7	Origin of Periodicity	208
10.8	Summary	212
	References	212
11	Quantum Dot Nanophotonic Waveguides	215
	<i>Lih Y. Lin and Chia-Jean Wang</i>	
11.1	Conceptual Formation and Modeling of the Device	216
11.1.1	QD Gain vs. Pump Power	218
11.1.2	FDTD Modeling for Interdot Coupling	220
11.1.3	Monte Carlo Simulation for Transmission Efficiency	221
11.2	From Concept to Realization – Fabrication of the Device	224
11.2.1	DNA-Directed Self-Assembly Fabrication	224
11.2.1.1	Self-Assembly Process and Characterization	224
11.2.1.2	Programmable DNA-Directed Self-Assembly	227
11.2.2	Self-Assembly Through APTES	228
11.2.2.1	Self-Assembly Process and Characterization	228
11.2.2.2	Multiple-QD-Type Waveguide Fabrication	231
11.2.3	Discussion on Fabrication Methods	232
11.3	How Well the Devices Work – A First Probe	233
11.3.1	Waveguiding with Flexibility	234
11.3.2	Loss Characterization	235
11.4	To Probe Further – Summary and Outlook	236
	References	238
12	Hierarchy in Optical Near-fields and its Application to Nanofabrication	241
	<i>Makoto Naruse, Takashi Yatsui, Hirokazu Hori, Kokoro Kitamura, and Motoichi Ohtsu</i>	
12.1	Introduction	241

12.2	Angular Spectrum Representation of Optical Near-Fields	242
12.3	Generation of Smaller-Scale Structures via Optical Near-Fields: A Theoretical Basis	244
12.4	Experiment	247
12.5	Conclusion	249
	References	250
	Index	253

