

Contents

1	An Overview of the Technological and Scientific Achievements of the Terahertz	1
1.1	Introduction	1
1.2	Terahertz Terminology	1
1.3	Terahertz Applications and Opportunities	2
1.3.1	Space	2
1.3.2	Plasma Fusion Diagnostics	4
1.3.3	Spectroscopy	4
1.3.4	Industrial	6
1.3.5	Communication	7
1.3.6	Simulating the Radar Scattering Signatures	7
1.3.7	T-Ray Imaging	8
1.3.8	Medical	11
1.3.9	Physics	12
1.3.10	Chemistry and Biology	14
1.4	Terahertz Components	16
1.4.1	THz Detectors	16
1.4.2	THz Sources	40
1.5	Theoretically Investigation of Terahertz-Pulse Generation and Detection	62
1.5.1	THz Pulse Generation and Detection Using Photoconductive Antenna (PC)	63
1.5.2	THz Pulse Generation and Detection Using Other Methods	65
1.5.3	THz Radiation from Bulk Semiconductor Microcavities	69
1.6	THz Detectors and Sources with Organic Materials	70
1.6.1	Conjugated Semiconducting Polymers	70
1.6.2	Organic EO Polymers	71
1.6.3	Organic EO Crystals	72

1.6.4	Solutions Containing Polar Molecules	78
References		78
2	Terahertz and Infrared Quantum Photodetectors	91
2.1	Introduction.	91
2.2	Detector Principles.	92
2.2.1	Noise Affects	93
2.2.2	Background Limited IR Performance	95
2.2.3	Quantum Cascade Detectors	95
2.2.4	Effects of Number of Periods and Doping Density on the Detector Parameters	101
2.2.5.	Quantum Dot Infrared Photodetectors.	103
2.3	Terahertz and Infrared Quantum Cascade Detectors	104
2.3.1	Dual Color Mid-Infrared Quantum Cascade Photodetector in a Coupled Quantum Well Structure . . .	107
2.3.2	A Dual-Color IR Quantum Cascade Photodetector with Two Output Electrical Signal	110
2.4	Terahertz Quantum Well Photodetector Based on Two-Photon Absorption	115
2.5	Quantum Dots THZ-IR Photodetector.	120
2.5.1	An Overview of Quantum Dot.	120
2.5.2	An Overview of Quantum Dots Photodetectors	123
2.5.3	Ultra-High Detectivity Room Temperature THZ-IR Photodetector Based on Resonant Tunneling Spherical Centered Defect Quantum Dot.	134
2.5.4	Terahertz Photodetector Based on Intersublevel Optical Absorption in Coupled Quantum Dots.	149
2.6	Terahertz and Infrared Photodetector Based on Electromagnetically Induced Transparency	152
2.6.1	Electromagnetically Induced Transparency Phenomena	152
2.6.2	EIT-Based Photodetection.	159
2.6.3	Terahertz Quantum Cascade Photodetector Based on Electromagnetically Induced Transparency	178
References		183
3	Terahertz and Infrared Quantum Cascade Lasers.	191
3.1	Introduction.	191
3.2	Quantum Cascade Laser Principles.	191
3.2.1	Radiative and Non-radiative Transitions in Semiconductor Heterostructures.	192
3.2.2	Resonant Tunneling Transport.	196
3.2.3	Quantum Cascade Lasers	197
3.2.4	Optical Gain	198

3.2.5	Threshold Current	199
3.2.6	Losses	199
3.2.7	Slope Efficiency	200
3.3	Terahertz Quantum Cascade Lasers	200
3.3.1	Terahertz QCL Structures	201
3.3.2	Drude Model	207
3.3.3	Terahertz-Waveguide	208
3.3.4	Distributed Feedback QCLs	210
3.4	Analysis of Transport Properties of THz QCLs	212
3.5	High Power QCLs	215
3.5.1	Photonic Crystal DFB QCLs	218
3.6	Dual-Wavelength Generation Based on Monolithic THz-IR QCL	219
3.6.1	Linear Frequency-Doubling in IR QCL	219
3.6.2	Dual Color Terahertz QCL	226
	References	234
	Index	239