

Contents

1	Introduction to Nonthermal Atmospheric Pressure Plasma: Physical and Chemical Basis	1
	Alexander A. Fridman, Michael Keidar, and Eun Ha Choi	
1.1	Introduction to Plasma Bioscience and Medicine	2
1.1.1	Plasma Medicine is a New Division of Medical Science and Technology	2
1.1.2	Controllability and Safety of Plasma	2
1.1.3	Plasma Application to Biology and Medicine from the Very First Steps Till Today	4
1.1.4	Plasma as a Helpful Tool for Medicine, Electric Discharges in Plasma Medicine	7
1.1.5	Plasma Chemistry: A Basic Foundation	8
1.1.6	Applied Plasma Medicine	10
1.2	Plasma for Cancer Therapy	12
1.2.1	Background	12
1.2.2	In Vivo Applications	14
1.2.3	Clinical Studies	16
1.3	Non-thermal Atmospheric Pressure Plasma Diagnostics	18
1.3.1	Optical Emission Spectroscopy (OES) for Plasma	18
1.3.2	Measurement of the Electron Density by Using Optical Interferometer	21
1.3.3	Measurement of the Plasma Radicals by Using Ultraviolet Absorption Spectroscopy	26
1.3.4	Plasma Parameter Characteristics for Industry and Biomedical Plasma Products	28
	References	31
2	Cancer Treatment and Immunomodulation by Nonthermal Plasma Technology	35
	Nagendra Kumar Kaushik, Neha Kaushik, and Eun Ha Choi	
2.1	Introduction	35

2.2	Plasma-Induced Anticancer Effects and Signaling Mechanism	38
2.2.1	Plasma-Based Activation of Immune Cells	41
2.3	Plasma-Based Immunogenic Effect	44
2.4	Conclusion and Future Prospective	52
	References	54
3	Cold Plasma in Dentistry	61
	Jae-Sung Kwon	
3.1	Introduction on Dentistry	61
3.1.1	Oral Tissues	61
3.1.2	Oral Environment	62
3.1.3	Common Dental Disease	63
3.2	Application of Cold Plasma on Dental Materials	63
3.2.1	Application of Cold Plasma on Dental Implant Surfaces	63
3.2.2	Application of Cold Plasma on Adherend for Improved Bonding	71
3.2.3	Application of Cold Plasma on Dental Materials for Other Purposes	72
3.3	Application of Cold Plasma on Dental Cells or Tissues	73
3.4	Others	75
	References	75
4	Nonthermal Plasma-Based Virus Inactivation and Sterilization	77
	Nagendra Kumar Kaushik, Yungoh Shin, Sehoon Ki, Ihn Han, Neha Kaushik, and Eun Ha Choi	
4.1	Introduction of Animal Viruses	77
4.1.1	Definition of Virus	77
4.1.2	Human Viral Epidemics of Recent Forty years	78
4.1.3	Structure and Function of Virus	78
4.1.4	Classification and Nomenclature of Animal Viruses	79
4.2	Overview of Emerging Human Coronaviruses	81
4.2.1	Common Cold Causing Coronaviruses in Human	81
4.2.2	SARS Causing Viruses	81
4.3	Plasma-Based Virus Inactivation Strategies, and Mechanisms	82
4.4	Conclusion and Future Prospective	88
	References	89
5	Cold Plasma Based Wound Healing Application	93
	Kai Masur	
5.1	Background/Introduction	93
5.2	Wound Healing	94
5.2.1	Acute Wounds	94

5.2.2	Chronic Wounds	95
5.3	Cold Atmospheric Pressure Plasma and Chronic Infected Wounds	96
5.3.1	Anti-Microbial Effects	96
5.3.2	Cold Plasma in Cell Culture	99
5.4	Animal Studies Applying Cold Plasma	101
5.5	Clinical Application of Cold Plasma for Wound Healing	102
5.6	Cellular Redox Balance Modulated by Cold Plasma	104
5.7	Summary	107
	References	108
6	Agriculture and Food Processing Applications	111
	Henrike Brust, Nicola Wannicke, and Gyungsoon Park	
6.1	Background	111
6.2	Application of Non-thermal Atmospheric Pressure Plasma to Prevent Seed Borne Infections	112
6.2.1	General Treatment of Seeds	112
6.2.2	Effect of Cold Plasma Treatment on Fungi	114
6.2.3	Effect of Plasma Treatment on Bacteria	126
6.2.4	Effect of Plasma Treatment on Viruses	131
6.3	Application of Non-thermal Atmospheric Pressure Plasma to Seed Germination and Plant Growth	134
6.3.1	Plasma Effects on Seed Surface Morphology	185
6.3.2	Chemical Modification of the Seed Surface	186
6.3.3	Alterations of Seed Surface Hydrophobicity	187
6.3.4	Alterations of Seed Water Absorbance	188
6.3.5	Plasma Effects on Seed Germination and Plant Growth Parameters	188
6.3.6	Plasma Effects on Seed and Plant Physiology	190
6.4	Application of Non-thermal Plasma to Food Sanitation	192
6.4.1	Vegetables and Fruits	192
6.4.2	Meats, Meat Products, and Fishes	203
6.4.3	Packaged Foods	204
6.4.4	Processed Foods	205
6.5	Application of Non-thermal Plasma to Food Quality and Functional Property	205
6.6	Conclusion and Future Perspectives	206
	References	206
7	Plasma Devices for Cosmetic and Aesthetic Treatment	229
	Ihn Han	
7.1	Plasma Devices	229
7.2	Opportunities for Plasma Devices in Cosmetics/Aesthetics Applications	230
7.3	Trends of Plasma Technology in Cosmetics and Marketing	232

7.4	Optimization of Plasma Dose for Wound Healing and Cancer Treatment	236
7.5	NBP Anti-Cancer Effect During in Vivo and in Vitro Application	236
7.6	Human Skin Anatomy	237
7.7	Methods of Enhancing Skin Permeability	239
7.8	Skin and Its Microenvironment	241
7.9	Chitosan Biocompatible Material as Skin Rejuvenation	241
7.10	Skin Treatment by Using Nonthermal Plasma	242
7.11	Plasma Activated Water Play Important Role in Skin Rejuvenation	244
7.12	Plasma Skin Regeneration Treatment in the Dermo-Cosmetic Application	245
7.12.1	Epithelialized Skin Diseases that Are Highly Contaminated with Germs	245
7.12.2	Wounded Epidermis and Germ-Contaminated Skin Diseases Treatment	246
7.12.3	The Effect of Plasma on the Skin Surface	248
	References	249
8	Clinical Studies on Cold Gas Plasma Applications: The Autonomous Patient and Getting Informed Consent for Treatment and Clinical Studies	257
	Hans-Robert Metelmann, Philine Henriette Doberschütz, and Christian Seebauer	
8.1	Background	257
8.2	Template	258
8.2.1	General Aspects of Plasma Medicine	258
8.2.2	Selection of Patients	259
8.2.3	Choice of Plasma Devices	260
8.2.4	Handling of Complications	260
8.2.5	Frequently Asked Questions	261
	References	264
9	Safety Aspects and Standardization	271
	Jinsung Choi, Young June Hong, Junsup Lim, Kai Masur, and Eun Ha Choi	
9.1	Background	271
9.2	Confirmation of Plasma ME for Wound Treatment	273
9.3	The Role of RONS in Cancer Therapy Protection Against Excessive Reactive Species	274
9.4	Plasma Current	276
9.5	Plasma Temperature	277
	References	278

10	Biological Effects of Pulsed High-Power Microwaves	281
	Sohail Mumtaz, Junsup Lim, Nagendra Kumar Kaushik, and Eun Ha Choi	
10.1	Introduction	282
10.1.1	Origin of Pulsed HPMW	282
10.2	Applications of HPMW	283
10.2.1	Military Based Applications	283
10.2.2	Industry Based Applications	283
10.2.3	Medical Applications	283
10.2.4	Communication Satellite and Astronomy-Based Applications	284
10.2.5	Spectroscopy	284
10.3	Important High Power Microwave Sources	284
10.3.1	Backward Wave Oscillator (BWO)	285
10.3.2	Gyrotrons	285
10.3.3	Magnetrons	285
10.3.4	Viricator	286
10.3.5	Basic Concept of Viricator	287
10.4	Introduction of Viricator Based Pulsed Power Generator, “Chundoong”	287
10.5	Formation of Virtual Cathode and HPMW Generation	288
10.6	Electromagnetic (EM) Field Interaction with Biological Systems	288
10.6.1	Mechanism for Action of EM Fields in Biology	290
10.7	The Biological Effects of EM Field of HPMW	291
10.7.1	Effect of EM Field on Skin	291
10.7.2	Effects of EM Field on the Reproductive system	292
10.7.3	Effect of EM Field on Brain	293
10.7.4	Biological Effect of High-Power Short Pulses of EM Field	295
10.7.5	Effect of Long-Time Exposure of EM Field	295
10.7.6	The Electric Field of HPMW Generated by Chundoong	296
10.7.7	Generation of Reactive Species by HPMW Exposure	297
10.7.8	Bacterial Inactivation by EM Field of Microwave Radiation	298
10.8	Summary	299
	References	300
Index	309