

Contents

Introduction.....	III
-------------------	-----

CHAPTER 1

Additive Manufacturing: Development of Sustainable Industrial Processes for Circular Economy Improvement	1
1.1 Additive Manufacturing: Essentials	3
1.1.1 Overview of Additive Manufacturing: AM Common Terms	3
1.2 Materials Challenges in Metal Additive Manufacturing	41
1.2.1 Structure-Property Variability in Metal AM.....	41
1.2.2 Solidification and Structure-Property Relationships in Metallic Materials	43
1.2.3 Microstructure Variability in Fusion-Based Metal Additive Manufacturing	53
1.2.4 Concluding Remarks	65
1.3 Correlation Between Process Parameters and Properties of Use: Example of Corrosion	69
1.3.1 Introduction.....	69
1.3.2 What is Corrosion? A Few Recalls	70
1.3.3 Influence of Metallurgical Parameters on Corrosion	84
1.3.4 Advanced Manufacturing Processes as Solutions to Corrosion Concerns	91
1.3.5 Conclusions	93
1.4 Additive Manufacturing, from Powder to <i>In Situ</i> Nanocomposites	97
1.4.1 Introduction.....	97
1.4.2 Additive Manufacturing	98
1.4.3 From Powder to Nanocomposite Powder	102
1.4.4 Nanocomposite Material Produced by L-PBF.....	108
1.4.5 Conclusion	110
1.5 Architecture-by-Design: Focus on Ceramic AM	113
1.5.1 Introduction.....	113
1.5.2 Development of Ceramics by Additive Manufacturing: State-of-the-Art	113
1.5.3 Formulation of a High-Resolution Printing Stereolithography Resin	115

1.5.4	Development of Porous Ceramics Using Stereolithography from Ceramic Powders	118
1.5.5	Preparation of Oxide and Oxycarbide Ceramics from Pre-ceramic Polymers	119
1.5.6	An Example of Application of the Approach: Optimized Thermomechanical Properties of Thermal Insulators	122
1.5.7	Conclusion	124
1.6	Some Aspects of Numerical Modelling for Additive Manufacturing	127
1.6.1	Introduction	127
1.6.2	Overview of Modelling Approaches for Additive Manufacturing	128
1.6.3	Focus 1: Multiphysics of Liquid Metal Pool	130
1.6.4	Focus 2: Numerical Prediction of Grain Structure Formation in Additively Manufactured 316L Stainless Steel	135
1.7	Packaged Electronic Additive Manufacturing	141
1.7.1	Introduction	141
1.7.2	Additive Manufacturing for Electronics	141
1.7.3	Additive Manufacturing for Electronic Packaging	149
1.7.4	Additive Manufacturing for Structural Electronics	151
1.7.5	Conclusion	158

CHAPTER 2

	Nanoobjects: Synthesis, Integration and Application to Energy and Transportation	161
2.1	Synthesis of Nanoobjects	163
2.1.1	Nucleation and Growth	163
2.1.2	Synthesis Processes	167
2.2	Integration of Nanoobjects	177
2.2.1	The Liquid Phase	177
2.2.2	The Solid Phase	178
2.2.3	The Gas Phase	183
2.3	Application of Nanoobjects to Energy and Transportation	189
2.3.1	Solar and Heat Conversion	189
2.3.2	Electrochemical Storage	195
2.3.3	Hydrogen	200
	References	211

CHAPTER 3

	Emerging Surface Engineering Processes	217
3.1	Thermal Spray – Cold Spray	219
3.1.1	Introduction	219
3.1.2	Principle: A Wide Range of Metallic Powder	219
3.1.3	Investigation for Upgrading the Impact Particle Velocity	225
3.1.4	Deposition	229

3.1.5	Applications	239
3.1.6	Conclusion	239
3.2	Thermal Spray – Suspension Plasma Spraying	241
3.2.1	Introduction	241
3.2.2	Principle: From Micrometer to Nanometer Powder	241
3.2.3	SPS: A Process to Control	244
3.2.4	Build-Up of the Coating	250
3.2.5	Potential Applications for Aeronautics	251
3.2.6	Conclusion	253
3.3	Physical Vapor Deposition: Principles, Ionized PVD and Examples of Application	255
3.3.1	Introduction	255
3.3.2	PVD Main Principles	256
3.3.3	Standard Direct Current (DC) Magnetron Sputtering (MS)	257
3.3.4	From DCMS to High Power Impulse Magnetron Sputtering (HiPIMS)	261
3.3.5	Cathodic Arc Deposition (CAD)	261
3.3.6	Examples of Application	265
3.3.7	Conclusions	269
3.4	Chemical Vapor Deposition	271
3.4.1	Introduction	271
3.4.2	Principles and Fundamentals	272
3.4.3	Thermal CVD: Hot-Wall <i>vs.</i> Cold-Wall	273
3.4.4	Activation in CVD Technologies	274
3.4.5	Specific CVD Processes	276
3.4.6	Precursor Tailoring for Metalorganic CVD	278
3.4.7	Process Optimization Through Monitoring and Process Modelling	278
3.4.8	Concluding Remarks: Historical and Contemporary Applications in Energy and Transport Fields	282
3.5	Atomic Layer Deposition	285
	References	289

CHAPTER 4

	New Drivers for Materials Science and Engineering	297
4.1	Material Resource Efficiency in Low Carbon Energy: Towards a More Circular Economy	299
4.1.1	Introduction & Definition of Strategic, Critical Materials	299
4.1.2	Current Issues in Material Resources	300
4.1.3	From Sobriety to Material Substitution	301
4.1.4	Case Studies in New Technologies for Energy: Materials and Processes	301
4.1.5	Circular Economy & Recycling	306
4.1.6	Social Acceptance, Ethical Issues <i>vs.</i> Education	309
4.1.7	Conclusion	310

4.2	Artificial Intelligence for Materials Science and Engineering	311
4.2.1	Introduction	311
4.2.2	Introduction to Artificial Intelligence	313
4.2.3	Qualification of Causality Relations	323
4.2.4	Properties and Performance Prediction for Process Optimization	326
4.2.5	Materials' Recommendation	329
4.2.6	Assistance in the Characterization of Materials	330
4.2.7	Conclusion	332
4.3	Integrative Approach for Safe Manufacturing	337
4.3.1	Introduction	337
4.3.2	Discussion	354
4.3.3	Conclusion	360
	Conclusion	365