
Contents

Foreword	xiii
Acknowledgements	xv
Preface	xvii
Note to Readers	xxi
Preamble	xxiii
Part 1. Introduction to the World of Wearables	1
Introduction to Part 1	3
Chapter 1. Definitions and Position	5
1.1. A few definitions	5
1.1.1. Wearables	5
1.1.2. Objects	6
1.1.3. Connected	6
1.1.4. IoT	6
1.1.5. Secured	7
1.1.6. Smart Wearables	7
1.2. The position of this book	7
Chapter 2. Non-textile and Textile Wearables	9
2.1. Non-textile Wearables or “accessories”	9
2.2. “Textile” Wearables	9

2.3. Smart textiles.	10
2.3.1. Definitions.	10
2.4. Materials	11
2.4.1. Textile material	11
2.4.2. Functional textile material	11
2.4.3. Smart textile material	12
2.5. Smart textile systems and their typologies.	12
2.5.1. Textile system.	12
2.5.2. Smart textile system	12
2.5.3. Textile system typologies	12
2.5.4. Level of integration of electronics in textiles.	13
2.5.5. Textiles with active functions	16
Chapter 3. The Market – the Applications	17
3.1. The world of the Internet of Things	17
3.2. The world of Wearables.	18
3.2.1. The global market of Wearables and their applications	18
3.2.2. The market of “accessory” Wearables	19
3.2.3. The smart Textiles market	23
3.3. A view of the market from the consumer side.	27
3.3.1. Purchase levers	27
3.3.2. The brakes to purchasing Wearables	27
3.3.3. The solutions that generate trust.	29
3.3.4. The innovation “hype” curve	30
Part 2. Constraints of a Wearable Project	35
Introduction to Part 2	37
Chapter 4. Aspects to Take into Consideration for Wearables, Smart Textiles and Smart Apparel	39
4.1. Financial and marketing aspects	40
4.1.1. “Sellable” versus “buyable”	40
4.2. Ergonomic aspects.	42
4.2.1. Mechanical shape and design versus ergonomy	42
4.2.2. User operating flexibility.	42
4.3. Technical aspects	43
4.3.1. Lifecycle of a new product.	43
4.3.2. Technical-economic feasibility	43
4.3.3. Design	44
4.3.4. Industrialization, manufacturing process and quality	44

4.4. Energy aspects	44
4.4.1. Energy supply of a Wearable	44
4.5. Industrial aspects.	46
4.6. Regulatory aspects and recommendations	47
4.6.1. Radio frequency regulations (RF)	48
4.6.2. Health recommendations	50
4.6.3. Regulations concerning “health”	51
4.6.4. Regulations for individual and societal freedom	54
4.6.5. The different data to protect in Wearables	59
4.6.6. Wearables, smart textiles, smart apparel and personal data	60
4.6.7. Regulation of PPE	67
4.6.8. Environmental regulations and recycling	70
4.7. Normative aspects	73
4.7.1. Why talk about normative aspects?	73
4.7.2. The ISO, CEN, IEC and CENELEC agencies	73
4.7.3. CEN – Comité Européen de Normalisation (European Standardization Committee)	74
4.7.4. IEC – International Electrotechnical Commission	74
4.7.5. ISO/AFNOR.	77
4.7.6. IEEE	78
4.7.7. ETSI	78
4.7.8. Summary.	78
4.8. Applicative aspects	79
4.8.1. Why speak of applicative aspects?	79
4.8.2. Pre-sale	79
4.8.3. Midway between pre-sale and sale	79
4.8.4. Sale.	79
4.8.5. Maintenance.	79
4.8.6. Post-sale	84
4.8.7. Recycling	86
4.9. Security aspects	86
4.9.1. The weak links	87
4.9.2. Potential remedies	89
4.9.3. Security target.	90
4.9.4. Levels of security applicable in Wearables.	91
4.9.5. Cryptography	94
4.9.6. Security and Wearables for the Consumer Market.	94
4.9.7. Vulnerabilities and attacks of the Wearable chain	96
4.10. Cost aspects.	97

Part 3. Examples of Non-textile Wearables and Smart Textiles and Apparel	99
Introduction to Part 3	101
Chapter 5. Examples of Non-textile Wearables	103
5.1. General public (consumer) type	103
5.1.1. Earpieces, headsets and earphones	103
5.1.2. Bracelet	104
5.1.3. Connected watches	108
5.1.4. Glasses	112
5.1.5. Shoes	113
5.1.6. Trackers – environmental tracking	115
5.1.7. For pets	118
5.2. The Luxury Style type	119
5.2.1. Example: Louis Vuitton	119
5.2.2. Example: Louboutin	120
5.2.3. Example: jewelry – connected ring – Icare	122
5.3. The sports type	122
5.3.1. Example: tennis racket	122
5.4. The automobile type	123
5.4.1. Presence detector	123
5.4.2. Detection and warning of drowsiness at the wheel	124
5.5. The medical types	126
5.5.1. Example: heart failure – CardioRenal	126
5.5.2. Example: diabetes treatment	127
5.5.3. Example: Dermatology – Feeligreen	128
5.6. The security type – PPE	129
5.6.1. Example: firefighters	129
5.6.2. Example: smart helmets	130
Chapter 6. Examples of Smart Fibers and Smart Textiles	133
6.1. A few words of introduction	133
6.2. Fibers	134
6.2.1. Natural fibers	135
6.2.2. Artificial fibers	135
6.3. Textile/fabric/cloth	137
6.3.1. Textile	137
6.3.2. Cloth	138
6.3.3. Texture	138
6.3.4. Ennoblement	138

6.4. A few words on technologies	141
6.4.1. Weaving with applied or integrated electronics	141
6.4.2. On wires	142
6.4.3. Optical fibers	149
Chapter 7. The Future of Smart Fibers and Smart Textiles	153
7.1. Wellbeing	154
7.1.1. Silver economy	154
7.1.2. Fitness	155
7.1.3. Sport	156
7.1.4. PPE – personal protective equipment	156
7.1.5. Medical	157
7.2. Smart fiber	160
7.2.1. Integration of high-tech in the textile substrate.	161
7.2.2. Examples of a few R&D projects	163
Chapter 8. Examples of Smart Apparel	169
8.1. Fashion	170
8.1.1. Luxury style	171
8.1.2. Street style and for the young	172
8.1.3. For haute couture	175
8.1.4. For well-being.	177
8.1.5. For sport/fitness.	178
8.1.6. For the medical field	180
8.1.7. For the field of “social care”.	189
8.1.8. For industrial/protective PPE clothing	192
Part 4. The Technologies Behind Wearables	199
Introduction to Part 4	201
Chapter 9. Components	203
9.1. Sensors	203
9.1.1. Sensors and physics.	204
9.1.2. Signal processing	205
9.1.3. Sensors frequently used in Wearables.	208
9.1.4. Analog front-end – AFE	218
9.2. CPU and power consumption.	235
9.2.1. For applications in fitness, health and the medical domain	235
9.2.2. Quantifying energy level	236
9.2.3. Energy harvesting.	239

9.3. Actuators	244
9.3.1. General points	244
9.3.2. Display and display units	245
9.3.3. Peculiarities of displays for luminous textile applications	248
9.3.4. Optical fibers	251
9.3.5. Liquid crystals	254
9.3.6. Electronic paper (e-paper) and flexible screens	254
9.3.7. Electrochromic materials	256
9.4. Printed circuit boards, connectors and electrodes	257
9.4.1. Printed circuit boards	257
9.4.2. Connectors	257
9.4.3. Measuring electrodes	259
Part 5. Wearables: Smart Apparel, RF Connectivity and Big Data	261
Introduction to Part 5	263
Chapter 10. RF Connectivity in Wearables	265
10.1. RF connectivity in Wearables	265
10.1.1. Brief rundown of the basics of radio frequency (RF)	266
10.1.2. Regulations and constraints in the field of RF communication	270
10.2. From Wearables to a whole connected world	273
10.2.1. RF connectivity in proximity to or distant from the Wearables	273
10.2.2. Short range (SR)	275
10.2.3. Medium range (MR)	280
10.2.4. Medium-range wide band	280
10.2.5. Long range (LR) – far field	283
10.2.6. Long range (tens of kilometers)	284
10.2.7. Long range (LR: LTN)	286
Chapter 11. Global Architecture of Wearables: Connected Textiles	295
11.1. Communication models in the IoT and Wearables	295
11.1.1. OSI model	295
11.1.2. TCP/IP model	297
11.1.3. A kind of conclusion	299
11.2. Architectures of Wearable solutions	299
11.2.1. Technological description of the whole chain	300
11.3. The very numerous protocols in use	302

Part 6. Description of the Wearables and Connected Textiles Chain	305
Chapter 12. Chain for a Connected Wearable	307
12.1. From the gateway to the server	307
12.1.1. Network access layer: IP	307
12.1.2. 6LoWPAN	308
12.2. The server	308
12.3. The broker	310
12.4. Return from Cloud server to end users	310
12.5. “Cloud”	311
12.5.1. Cloud and Fog computing	311
12.5.2. Types of Cloud computing	312
12.6. Big data	313
Part 7. Concrete Realization of a Wearables/Smart Textiles Solution: Examples and Costs	315
Introduction to Part 7	317
Chapter 13. Examples of Concrete Realization of Wearables: Smart Connected Apparel	319
13.1. General electronic architecture of a Wearable	319
13.1.1. Division of the electronic technologies	319
13.2. Physical architecture of a communicating Wearable	321
13.2.1. The BASE	321
13.2.2. Wearable/smart apparel	322
13.2.3. Compulsory steps in the concrete realization of the Wearable	323
Chapter 14. Cost Aspects	327
14.1. CAPEX and OPEX.	327
14.1.1. CAPEX.	328
14.1.2. OPEX.	334
14.2. In conclusion	336
Conclusion	337
Appendix: Reputable Players	339
References	343
Index	345