



TABLE OF CONTENTS

1 EXECUTIVE SUMMARY..... 33

1.1 The evolution of electronics..... 33

 1.1.1 The wearables revolution..... 34

 1.1.2 Flexible, thin, and large-area form factors..... 36

1.2 What are flexible and stretchable electronics?..... 37

 1.2.1 From rigid to flexible and stretchable..... 37

 1.2.2 Organic and printed electronics..... 39

 1.2.3 New conductive materials..... 40

1.3 Growth in flexible and stretchable electronics market..... 44

 1.3.1 Recent growth in printable, flexible and stretchable products..... 44

 1.3.2 Future growth..... 44

 1.3.3 Nanotechnology as a market driver..... 45

 1.3.4 Growth in remote health monitoring and diagnostics..... 46

2 RESEARCH METHODOLOGY..... 49

3 PRINTABLE, FLEXIBLE AND STRETCHABLE ELECTRONIC MATERIALS AND COMPOSITES..... 50

3.1 CARBON NANOTUBES..... 50

 3.1.1 Properties..... 50

 3.1.2 Properties utilized in printable, flexible and stretchable electronics..... 51

 3.1.2.1 Single-walled carbon nanotubes..... 52

 3.1.3 Applications in printable, flexible and stretchable electronics..... 53

3.2 CONDUCTIVE POLYMERS (CP)..... 55

 3.2.1 Properties..... 56



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

3.2.1.1	PDMS.....	56
3.2.1.2	PEDOT: PSS.....	56
3.2.2	Properties utilized in printable, flexible and stretchable electronics.....	57
3.2.3	Applications in printable, flexible and stretchable electronics.....	58
3.3	GRAPHENE.....	58
3.3.1	Properties.....	58
3.3.2	Properties utilized in printable, flexible and stretchable electronics.....	60
3.3.3	Applications in printable, flexible and stretchable electronics.....	61
3.4	METAL MESH.....	63
3.4.1	Properties.....	63
3.4.2	Properties utilized in printable, flexible and stretchable electronics.....	65
3.4.3	Applications in printable, flexible and stretchable electronics.....	65
3.5	SILVER INK (Flake, nanoparticles, nanowires, ion).....	66
3.5.1	Silver flake.....	66
3.5.2	Silver (Ag) nanoparticle ink.....	67
3.5.2.1	Conductivity.....	68
3.5.3	Silver nanowires.....	68
3.5.4	Prices.....	70
3.5.4.1	Cost for printed area.....	70
3.6	COPPER INK.....	71
3.6.1	Silver-coated copper.....	72
3.6.2	Copper (Cu) nanoparticle ink.....	72
3.6.3	Prices.....	72
3.7	NANOCELLULOSE.....	73
3.7.1	Properties.....	73
3.7.2	Properties utilized in printable, flexible and stretchable electronics.....	75



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

3.7.3	Applications in printable, flexible and stretchable electronics.....	76
3.7.3.1	Nanopaper.....	77
3.7.3.2	Paper memory.....	79
3.8	NANOFIBERS.....	80
3.8.1	Properties.....	80
3.8.2	Properties utilized in printable, flexible and stretchable electronics.....	80
3.8.3	Applications in printable, flexible and stretchable electronics.....	81
3.9	QUANTUM DOTS.....	81
3.9.1	Properties.....	81
3.9.2	Properties utilized in printable, flexible and stretchable electronics.....	83
3.9.3	Applications in printable, flexible and stretchable electronics.....	83
3.10	GRAPHENE AND CARBON QUANTUM DOTS.....	85
3.10.1	Properties.....	86
3.10.2	Applications in printable, flexible and stretchable electronics.....	87
3.11	OTHER TYPES.....	87
3.11.1	Gold (Au) nanoparticle ink.....	87
3.11.2	Siloxane inks.....	88
3.12	OTHER 2-D MATERIALS.....	88
3.12.1	Black phosphorus/Phosphorene.....	88
3.12.1.1	Properties.....	88
3.12.1.2	Applications in printable, flexible and stretchable electronics.....	90
3.12.2	Graphitic carbon nitride (g-C ₃ N ₄).....	91
3.12.2.1	Properties.....	91
3.12.2.2	Applications in printable, flexible and stretchable electronics.....	92
3.12.3	Germanene.....	92
3.12.3.1	Properties.....	93
3.12.3.2	Applications in printable, flexible and stretchable electronics.....	93



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

3.12.4	Graphdiyne.....	94
3.12.4.1	Properties.....	94
3.12.4.2	Applications in printable, flexible and stretchable electronics.....	95
3.12.5	Graphane.....	95
3.12.5.1	Properties.....	95
3.12.5.2	Applications in printable, flexible and stretchable electronics.....	96
3.12.6	Hexagonal boron nitride.....	96
3.12.6.1	Properties.....	97
3.12.6.2	Applications in printable, flexible and stretchable electronics.....	98
3.12.7	Molybdenum disulfide (MoS ₂).....	98
3.12.7.1	Properties.....	99
3.12.7.2	Applications in printable, flexible and stretchable electronics.....	100
3.12.8	Rhenium disulfide (ReS ₂) and diselenide (ReSe ₂).....	101
3.12.8.1	Properties.....	102
3.12.8.2	Applications in printable, flexible and stretchable electronics.....	102
3.12.9	Silicene.....	103
3.12.9.1	Properties.....	103
3.12.9.2	Applications in printable, flexible and stretchable electronics.....	104
3.12.10	Stanene/tinene.....	105
3.12.10.1	Properties.....	105
3.12.10.2	Applications in printable, flexible and stretchable electronics.....	106
3.12.11	Tungsten diselenide.....	106
3.12.11.1	Properties.....	107
3.12.11.2	Applications in printable, flexible and stretchable electronics.....	107
3.12.12	Antimonene.....	107
3.12.12.1	Properties.....	108
3.12.12.2	Applications.....	108



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

3.12.13	Indium selenide.....	108
3.12.13.1	Properties.....	108
3.12.13.2	Applications.....	109
4	WEARABLE ELECTRONICS AND IOT.....	111
4.1	MARKET DRIVERS AND TRENDS.....	111
4.2	APPLICATIONS.....	114
4.2.1	Current state of the art.....	115
4.2.2	Advanced materials solutions.....	117
4.2.3	Transparent conductive films.....	118
4.2.3.1	Materials in conductive layers.....	118
4.2.3.2	Nanomaterials used in TCFs.....	123
4.2.4	Wearable sensors.....	130
4.2.4.1	Current stage of the art.....	130
4.2.4.2	Advanced materials solutions.....	132
4.2.4.3	Nanomaterials.....	133
4.2.4.4	Electroactive polymers (EAPs).....	136
4.2.4.5	Wearable gas sensors.....	137
4.2.4.6	Wearable strain sensors.....	138
4.2.4.7	Wearable tactile sensors.....	138
4.2.4.8	Industrial monitoring.....	139
4.2.4.9	Military.....	140
4.2.5	IoT and smart packaging.....	141
4.2.6	Augmented reality (AR) smart glasses.....	142
4.2.7	Self-healing soft conductive materials.....	142
4.3	GLOBAL MARKET SIZE.....	144
4.4	COMPANY PROFILES.....	148-
	182 (78 company profiles)	



5 PRINTABLE, FLEXIBLE AND STRETCHABLE MEDICAL AND HEALTHCARE ELECTRONICS..... 184

5.1 MARKET DRIVERS AND TRENDS.....	184
5.2 APPLICATIONS.....	186
5.2.1 Current state of the art.....	186
5.2.2 Advanced materials solutions.....	192
5.2.2.1 Skin sensors.....	192
5.2.2.2 Nanomaterials-based devices.....	193
5.2.3 Printable, flexible and stretchable health monitors.....	194
5.2.3.1 Patch-type skin sensors.....	196
5.2.3.2 Skin temperature monitoring.....	200
5.2.3.3 Hydration sensors.....	201
5.2.3.4 Wearable sweat sensors.....	202
5.2.3.5 UV patches.....	203
5.2.3.6 Smart footwear.....	205
5.3 GLOBAL MARKET SIZE.....	205
5.4 COMPANY PROFILES.....	207-
226 (44 company profiles)	

6 PRINTABLE, FLEXIBLE AND STRETCHABLE ELECTRONIC TEXTILES AND APPAREL..... 227

6.1 MARKET DRIVERS AND TRENDS.....	227
6.2 APPLICATIONS.....	229
6.2.1 Current state of the art.....	231
6.2.2 Advanced materials solutions.....	233
6.2.3 Conductive yarns.....	239
6.2.4 Conductive coatings.....	240
6.2.5 Smart helmets.....	242
6.2.6 Solar energy harvesting textiles.....	243



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

6.2.7	Flexible display and sensor apparel.....	244
6.2.8	Electroluminescent textiles.....	245
6.3	GLOBAL MARKET SIZE.....	246
6.4	COMPANY PROFILES.....	249-
	269 (48 company profiles)	

**7 PRINTABLE, FLEXIBLE AND STRETCHABLE ENERGY STORAGE AND
CONVERSION..... 270**

7.1	MARKET DRIVERS AND TRENDS.....	270
7.2	APPLICATIONS.....	272
7.2.1	Current state of the art.....	272
7.2.2	Advanced materials solutions.....	274
7.2.2.1	Flexible and stretchable batteries.....	274
7.2.2.2	Flexible and stretchable supercapacitors.....	276
7.2.2.3	Fiber-shaped Lithium-Ion batteries.....	279
7.2.2.4	Flexible OLED lighting.....	279
7.2.2.5	Quantum dot lighting.....	280
7.2.2.6	Stretchable piezoelectric energy harvesting.....	282
7.2.2.7	Stretchable triboelectric energy harvesting.....	283
7.3	GLOBAL MARKET SIZE.....	283
7.4	COMPANY PROFILES.....	288-
	300 (30 company profiles)	

**8 PRINTABLE, FLEXIBLE AND STRETCHABLE DISPLAYS AND
COMPONENTS..... 301**

8.1	MARKET DRIVERS AND TRENDS.....	301
8.2	APPLICATIONS.....	302
8.2.1	Printable, flexible and stretchable circuit boards and interconnects.....	304
8.2.2	Printable, flexible and stretchable transistors.....	304
8.2.3	Flexible displays.....	305
8.2.3.1	Flexible LCDs.....	307



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

8.2.3.2	Flexible OLEDs (FOLED).....	308
8.2.3.3	Flexible AMOLED.....	309
8.2.3.4	Flexible microLEDs.....	312
8.2.3.5	Flexible electrophoretic displays.....	312
8.3	GLOBAL MARKET SIZE.....	313
8.4	COMPANY PROFILES.....	314-
	324 (30 company profiles)	

9 PRINTABLE, FLEXIBLE AND STRETCHABLE CONDUCTIVE INKS 325

9.1	MARKET DRIVERS AND TRENDS.....	325
9.2	CONDUCTIVE INK TYPES.....	327
9.3	PRINTING METHODS.....	328
9.3.1	Nanoparticle ink.....	331
9.4	Sintering.....	332
9.5	Conductive Filaments.....	333
9.6	Conductive films, foils and grids.....	333
9.7	Inkjet printing In flexible electronics.....	333
9.8	APPLICATIONS.....	334
9.8.1	Current products.....	334
9.8.2	Advanced materials solutions.....	335
9.8.3	RFID.....	339
9.8.4	Smart labels and packaging.....	341
9.8.5	Smart clothing.....	342
9.8.6	Printable sensors.....	342
9.8.7	Printed batteries.....	342
9.8.8	Printable antennas.....	344
9.8.9	In-mold electronics.....	345
9.8.10	Printed transistors.....	346



9.9 GLOBAL MARKET SIZE.....	347
9.10 COMPANY PROFILES.....	350-
396 (108 company profiles)	
10 REFERENCES.....	397

TABLES

Table 1: Evolution of wearable devices, 2011-2018.....	34
Table 2: Advanced materials for printable, flexible and stretchable sensors and Electronics-Advantages and disadvantages.....	41
Table 3: Sheet resistance (RS) and transparency (T) values for transparent conductive oxides and alternative materials for transparent conductive electrodes (TCE).....	42
Table 4: Markets for wearable devices and applications.....	44
Table 5: Properties of CNTs and comparable materials.....	50
Table 6: Companies developing carbon nanotubes for applications in printable, flexible and stretchable electronics.....	54
Table 7: Types of flexible conductive polymers, properties and applications.....	57
Table 8: Properties of graphene.....	59
Table 9: Companies developing graphene for applications in printable, flexible and stretchable electronics.....	61
Table 10: Advantages and disadvantages of fabrication techniques to produce metal mesh structures.....	64
Table 11: Types of flexible conductive polymers, properties and applications.....	65
Table 12: Companies developing metal mesh for applications in printable, flexible and stretchable electronics.....	66
Table 13: Nanocellulose properties.....	73
Table 14: Properties and applications of nanocellulose.....	74
Table 15: Properties of flexible electronics-cellulose nanofiber film (nanopaper).....	75
Table 16: Properties of flexible electronics cellulose nanofiber films.....	77
Table 17: Companies developing nanocellulose for applications in printable, flexible and stretchable electronics.....	79
Table 18: Companies developing quantum dots for applications in printable, flexible and stretchable electronics.....	84



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

Table 19: Schematic of (a) CQDs and (c) GQDs. HRTEM images of (b) C-dots and (d) GQDs showing combination of zigzag and armchair edges (positions marked as 1–4).....	86
Table 20: Properties of graphene quantum dots.....	86
Table 21: Electronic and mechanical properties of monolayer phosphorene, graphene and MoS ₂ .	90
Table 22: Market drivers for printable, flexible and stretchable sensors for wearable electronics and IoT.....	111
Table 23: Wearable electronics devices and stage of development.....	115
Table 24: Transparent conductive switches-PEDOT.....	119
Table 25: Comparison of ITO replacements.....	119
Table 26: Applications in printable, flexible and stretchable sensors, by advanced materials type and benefits thereof.....	120
Table 27: Graphene properties relevant to application in sensors.....	135
Table 28: Companies developing smart packaging for electronics.....	141
Table 29: Companies developing AR smart glasses.....	142
Table 30: Global market for wearable electronics, 2015-2030, by application, billions \$.....	145
Table 31: Global transparent conductive electrodes market forecast by materials type, 2012-2030, millions \$.....	146
Table 32: Market drivers for printable, flexible and stretchable medical and healthcare sensors and wearables.....	184
Table 33: Wearable medical device products and stage of development.....	188
Table 34: Applications in flexible and stretchable health monitors, by advanced materials type and benefits thereof.....	194
Table 35: Applications in patch-type skin sensors, by materials type and benefits thereof.....	198
Table 36: Companies developing electronic skin patches.....	199
Table 37: Market drivers for printable, flexible and stretchable electronic textiles and apparel....	227
Table 38: Types of smart textiles.....	229
Table 39: Examples of smart textile products.....	230
Table 40: Currently available technologies for smart textiles.....	231
Table 41: E-textiles and apparel and stage of development.....	232
Table 42: Applications in textiles, by advanced materials type and benefits thereof.....	234



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

Table 43: Nanocoatings applied in the textiles industry-type of coating, nanomaterials utilized, benefits and applications.....	235
Table 44: Applications and benefits of graphene in textiles and apparel.....	240
Table 45: Global smart clothing, interactive fabrics and apparel market.....	246
Table 46: Global market for printable, flexible and stretchable electronic textiles and apparel, 2015-2030 (billion \$).....	247
Table 47: Market drivers for printable, flexible and stretchable electronic energy storage and conversion.....	270
Table 48: Wearable energy and energy harvesting devices and stage of development.....	273
Table 49: Applications in flexible and stretchable batteries, by materials type and benefits thereof.....	275
Table 50: Companies producing flexible and stretchable batteries.....	276
Table 51: Applications in flexible and stretchable supercapacitors, by nanomaterials type and benefits thereof.....	278
Table 52: Applications in energy harvesting textiles, by nanomaterials type and benefits thereof.	281
Table 53: Potential addressable market for thin film, flexible and printed batteries.....	283
Table 54: Global market for printable, flexible and stretchable batteries, 2015-2030 (billion \$)...	286
Table 55: Global market for printable, flexible and stretchable solar, 2015-2030 (billion \$).....	286
Table 56: Global market for printable, flexible and stretchable lighting, 2015-2030 (billion \$).....	287
Table 57: Market drivers for printable, flexible and stretchable displays and electronic components.....	301
Table 58: Applications in flexible and stretchable circuit boards, by advanced materials type and benefits thereof.....	304
Table 59: Price comparison of thin-film transistor (TFT) electronics technology.....	305
Table 60: Global market for printable, flexible and stretchable displays, 2015-2030 (billion \$)....	313
Table 61: Market drivers for printable, flexible and stretchable conductive inks.....	325
Table 62: Typical conductive ink formulation.....	327
Table 63: Characteristics of analog printing processes for conductive inks.....	329
Table 64: Characteristics of digital printing processes for conductive inks.....	330
Table 65: Printable electronics products.....	334
Table 66: Comparative properties of conductive inks.....	335



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

Table 67: Applications in conductive inks by type and benefits thereof.....	336
Table 68: Opportunities for advanced materials in printed electronics.....	341
Table 69: Applications in flexible and stretchable batteries, by nanomaterials type and benefits thereof.....	343
Table 70: Price comparison of thin-film transistor (TFT) electronics technology.....	346
Table 71: Main markets for conductive inks, applications and revenues.....	347
Table 72: Conductive inks in the printable, flexible and stretchable electronics market 2017-2030 revenue forecast (million \$), by ink types.....	350

FIGURES

Figure 1: Evolution of electronics.....	34
Figure 2: Wove Band.....	37
Figure 3: Wearable graphene medical sensor.....	39
Figure 4: Applications timeline for organic and printed electronics.....	40
Figure 5: Mimo Baby Monitor.....	47
Figure 6: Wearable health monitor incorporating graphene photodetectors.....	48
Figure 7: Schematic of single-walled carbon nanotube.....	52
Figure 8: Stretchable SWNT memory and logic devices for wearable electronics.....	53
Figure 9: Stretchable carbon aerogel incorporating carbon nanotubes.....	55
Figure 10: Graphene layer structure schematic.....	60
Figure 11: Flexible graphene touch screen.....	61
Figure 12: Foldable graphene E-paper.....	61
Figure 13: Large-area metal mesh touch panel.....	64
Figure 14: Silver nanocomposite ink after sintering and resin bonding of discrete electronic components.....	68
Figure 15: Flexible silver nanowire wearable mesh.....	70
Figure 16: Copper based inks on flexible substrate.....	72
Figure 17: Cellulose nanofiber films.....	76
Figure 18: Nanocellulose photoluminescent paper.....	76



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

Figure 19: LEDs shining on circuitry imprinted on a 5x5cm sheet of CNF.....	77
Figure 20: Foldable nanopaper.....	78
Figure 21: Foldable nanopaper antenna.....	79
Figure 22: Paper memory (ReRAM).....	79
Figure 23: Quantum dot.....	82
Figure 24: The light-blue curve represents a typical spectrum from a conventional white-LED LCD TV. With quantum dots, the spectrum is tunable to any colours of red, green, and blue, and each Color is limited to a narrow band.....	82
Figure 25: Black phosphorus structure.....	88
Figure 26: Black Phosphorus crystal.....	89
Figure 27: Bottom gated flexible few-layer phosphorene transistors with the hydrophobic dielectric encapsulation.....	91
Figure 28: Graphitic carbon nitride.....	92
Figure 29: Schematic of germanene.....	93
Figure 30: Graphdiyne structure.....	94
Figure 31: Schematic of Graphane crystal.....	95
Figure 32: Structure of hexagonal boron nitride.....	97
Figure 33: Structure of 2D molybdenum disulfide.....	99
Figure 34: SEM image of MoS ₂	100
Figure 35: Atomic force microscopy image of a representative MoS ₂ thin-film transistor.....	100
Figure 36: Schematic of the molybdenum disulfide (MoS ₂) thin-film sensor with the deposited molecules that create additional charge.....	101
Figure 37: Schematic of a monolayer of rhenium disulphide.....	102
Figure 38: Silicene structure.....	103
Figure 39: Monolayer silicene on a silver (111) substrate.....	104
Figure 40: Silicene transistor.....	105
Figure 41: Crystal structure for stanene.....	105
Figure 42: Atomic structure model for the 2D stanene on Bi ₂ Te ₃ (111).....	106
Figure 43: Schematic of tungsten diselenide.....	107



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

Figure 44: Schematic of Indium Selenide (InSe).....	109
Figure 45: Covestro wearables.....	117
Figure 46: Royole flexible display.....	118
Figure 47: Panasonic CNT stretchable Resin Film.....	120
Figure 48: Flexionet conductive film.....	123
Figure 49: Bending durability of Ag nanowires.....	126
Figure 50: NFC computer chip.....	127
Figure 51: NFC translucent diffuser schematic.....	128
Figure 52: Softceptor sensor.....	130
Figure 53: BeBop Media Arm Controller.....	131
Figure 54: LG Innotek flexible textile pressure sensor.....	131
Figure 55: C2Sense flexible sensor.....	132
Figure 56: <hitoe> nanofiber conductive shirt original design(top) and current design (bottom)..	133
Figure 57: Garment-based printable electrodes.....	134
Figure 58: Wearable gas sensor.....	137
Figure 59: BeBop Sensors Marcel Modular Data Gloves.....	139
Figure 60: BeBop Sensors Smart Helmet Sensor System.....	139
Figure 61: Torso and Extremities Protection (TEP) system.....	140
Figure 62: Global market for wearable electronics, 2015-2030, by application, billions \$.....	144
Figure 63: Global transparent conductive electrodes market forecast by materials type, 2012-2030, millions \$.....	147
Figure 64: BITalino systems.....	158
Figure 65: Connected human body.....	187
Figure 66: Flexible, lightweight temperature sensor.....	188
Figure 67: Prototype ECG sensor patch.....	192
Figure 68: Graphene-based E-skin patch.....	193
Figure 69: Wearable bio-fluid monitoring system for monitoring of hydration.....	195
Figure 70: Smart mouth guard.....	196



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

Figure 71: Smart e-skin system comprising health-monitoring sensors, displays, and ultra flexible PLEDs.....	197
Figure 72: Graphene medical patch.....	198
Figure 73: TempTraQ wearable wireless thermometer.....	200
Figure 74: Mimo baby monitor.....	201
Figure 75: Nanowire skin hydration patch.....	201
Figure 76: Wearable sweat sensor.....	202
Figure 77: GraphWear wearable sweat sensor.....	203
Figure 78: My UV Patch.....	204
Figure 79: Overview layers of L'Oreal skin patch.....	205
Figure 80: Global medical and healthcare smart textiles and wearables market, 2015-2030, billions \$.....	206
Figure 81: Global medical and healthcare smart textiles and wearables market, 2015-2030, billions \$.....	207
Figure 82: Omniphobic-coated fabric.....	233
Figure 83: Conductive yarns.....	240
Figure 84: Work out shirt incorporating ECG sensors, flexible lights and heating elements.....	242
Figure 85: Schematic illustration of the fabrication concept for textile-based dye-sensitized solar cells (DSSCs) made by sewing textile electrodes onto cloth or paper.....	243
Figure 86: Flexible Shirt and Flexible Top Hat.....	244
Figure 87 Global smart clothing, interactive fabrics and apparel sales by market segment, 2017.	247
Figure 88: Global market for printable, flexible and stretchable electronic textiles and apparel, 2015-2030 (billion \$).....	248
Figure 89: Energy harvesting textile.....	271
Figure 90: StretchSense Energy Harvesting Kit.....	272
Figure 91: LG Chem Hexagonal battery.....	273
Figure 92: Printed 1.5V battery.....	275
Figure 93: Energy densities and specific energy of rechargeable batteries.....	277
Figure 94: Stretchable graphene supercapacitor.....	278
Figure 95: LG OLED flexible lighting panel.....	280



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

Figure 96: Flexible OLED incorporated into automotive headlight.....	280
Figure 97: Flexible & stretchable LEDs based on quantum dots.....	281
Figure 98: Demand for thin film, flexible and printed batteries 2015, by market.....	285
Figure 99: Demand for thin film, flexible and printed batteries 2030, by market.....	286
Figure 100: Global market for printable, flexible and stretchable batteries, 2015-2030 (billion \$).	286
Figure 101: Global market for printable, flexible and stretchable solar, 2015-2030 (billion \$).....	287
Figure 102: Global market for printable, flexible and stretchable lighting, 2015-2030 (billion \$)..	288
Figure 103: LG Display LG Display 77-inch flexible transparent OLED display.....	302
Figure 104: Thin film transistor incorporating CNTs.....	305
Figure 105: Carbon nanotubes flexible, rechargeable yarn batteries incorporated into flexible, rechargeable yarn batteries.....	306
Figure 106: Flexible LCD.....	307
Figure 107: "Full Active™ Flex".....	307
Figure 108: FOLED schematic.....	309
Figure 109: Foldable display.....	310
Figure 110: Stretchable AMOLED.....	310
Figure 111: LGD 12.3" FHD Automotive OLED.....	311
Figure 112 Paper-like foldable AMOLED screen.....	311
Figure 113: LECTUM® display.....	313
Figure 114: Global market for printable, flexible and stretchable displays, 2015-2030 (billion \$).	314
Figure 115: BGT Materials graphene ink product.....	339
Figure 116: Flexible RFID tag.....	340
Figure 117: Enfucell Printed Battery.....	344
Figure 118: Graphene printed antenna.....	344
Figure 119: Printed antennas for aircraft.....	345
Figure 120: Stretchable material for formed an in-molded electronics.....	346
Figure 121: Wearable patch with a skin-compatible, pressure-sensitive adhesive.....	346
Figure 122: Thin film transistor incorporating CNTs.....	346



The Global Market for Printable, Flexible and Stretchable Electronics to 2030

Figure 123: Conductive inks in the printable, flexible and stretchable electronics market 2017-2030 revenue forecast (million \$), by ink types..... 349