

- action primitives, 339
- active electrical components, 2
- activities, 339
- activity-aware smart textiles
  - signal processing technologies, 329–57
    - activity-aware applications, 331–2
    - activity recognition principles, 339–41
    - experimental aspects, 351–6
    - from on-body sensing to smart assistants, 329–31
    - future trends, 356–7
    - sensing principles for activity recognition, 332–9
    - signal processing and pattern analysis, 342–51
- Adidas International, 376
- Adidas Micoach system, 436
- AiQ Smart Clothing Inc., 385
- airjet spinning, 196–7
  - process, 197
- airjet technology, 204, 207
- aluminium, 40–1
- ambient displays, 71
- ambient illumination, 80
  - colour changing effect, 81
  - photonic bandgap (PBG) fibre reflective properties, 85
- anisotropic conductive adhesives (ACA), 296
- annotation, 352
- anomaly detection, 349
- architectural applications, 468–87, 472–81
  - actuators, 476, 477, 479, 481
  - airship hanger and human weight-controlled/operating building installation, 469
  - clay boards with embedded microcapsuled PCM and glass textiles, 478
  - future trends, 481–7
    - exterior textiles and actuators, 481
    - green gelatine surface with mold fungus, 484
    - interior textiles, 486–7
    - kinetic luminescent skin called *glowingSkin I*, 485
    - multilayered, multifunctional luminescent skin called *glowingSkin II*, 484
    - new actuator II, 486
    - Polyreagible Mechanomembrane* showing different stages of construction, 483
    - proposal for a flat structured constructed using *nanobots*, 485
    - thermoactive strips and actuators consisting of PVC with carbon fibres, 482
  - geotextile with water-swellaable bentonite, 476
  - hood and loop fastener with nickel-titanium alloy hooks, 477
  - hygro-active strips and actuators, 479
  - key themes in modern architecture, 468–70
  - light-emitting metal mesh, 474
  - modified metal mesh with embedded phosphorescent fibres, 478
  - new actuators, 480
  - passive components which could be used in smart textiles, 472
  - possible active components for smart textiles, 473
  - PVC-based membrane covered with photocatalytic layer, 476
  - self-cleaning membranes, 474
  - self-heating textiles, 474
  - shape memory interior textiles, 474, 477
  - smart materials, 470–2
    - different types of smart materials, 471
    - energy-generating and exchanging smart materials, 470–1
    - matter-exchanging smart materials, 472
    - property-changing smart materials, 470
  - smart textile consisting of metal mesh and LEDs, 475
  - smart textiles with rows of linear oriented LEDs, 479
- atlas weave, 205
- atomic layer deposition (ALD), 235
- Au, R., 390
- audio-tag system, 254–5
  - wearable audio system, 255
- automotive applications, 444–66

- electric vehicles impact on smart textiles
  - applications, 463–5
  - energy consumption of car components, 463
  - energy efficient design of all components, 464–5
  - lightweight construction, 464
  - Smart Concept Car, 465
  - thermal insulation of the cabin, 464
- future trends, 465–6
- key safety and quality requirements, 461–2
  - typical environmental conditions for car components, 462
- potential applications of smart textile
  - technology in vehicles, 446–7
  - roof and floor, 447
  - seat, 447
  - seatbelt, 447
  - steering wheel, 447
- prototypes in vehicles, 450–61
  - block diagram and prototype of steering wheel with vital signal sensors, 459
  - ECG measurement on real road, 458
  - ECG measurement set-up, 456
  - ECG seat cover, 458
  - ECG-seat with textile electrodes, 454
  - ECG signal with QRS complex, 453
  - intelligent cabin, 451
  - measurement principle, 454–9
  - occupant detection and classification
    - system with textile sensor, 460–1
  - OCS with textile sensor, 461
  - positions of electrodes in car seat, 455
  - potential distribution caused by heart activity, 455
  - realisation of ‘intelligent cabin’ vision, 454
  - steering wheel mounted in car and with displayed measurement values, 460
  - steering wheel with vital sensors, 459–60
  - textile multilayer electrode prototype, 457
- smart-textile applications and their potential
  - for use in cars, 449–50
  - ECG T-shirt and textile electrode, 449
  - lighting, 450
  - switches and touch pads, 449–50
  - textile switches, 450
- social and technological trends, 445
- textiles in vehicles, 445–9
  - smart-textile process, 448
  - tabulated textile intelligence classification, 446
  - textile circuit board, 448
  - textile intelligence classification, 446
- batteries, 307
- BioHarness, 436
- Bionic Composite Technologies AG, 376–7
- BIOTEX project, 430–1
- blogs, 18
- BMBF project, 450
- body postures, 340
- bonding, 296–7
- Bragg fibre *see* photonic bandgap (PBG) fibre
- Bragg reflector, 79–80
- braiding, 212–18
  - biaxial and triaxial braid, 216
  - flat and circular braid, 214
  - machine elements, 214
  - path of carriers, 215
  - third yarn system on a braiding machine, 216
- brazing, 293
- bundle wire drawing, 52–3
- business models, 382–3
- capacitive sensing, 154–5
- capacitor fibre length, 166–8
  - fibre capacitance and resistivity dependence, 167
- carbon, 48
- carbon black (CB), 43, 201
- carbon filler, 130
- carbon nanofibres, 95–6
  - SEM images of PAN nanofibre bundle, 97
- carbon nanotube (CNT), 44–5, 94–5, 201, 304
  - fibres, 44
  - filler material in polymeric fibres and filaments, 44–5
  - SEM and TEM images, 95
  - surface layers on textile structures, 45
  - wet spinning, 54
- CEN/TR 16298 (DIN SPEC 60298):2012–02, 446
- chemical reduction, 104, 106
- chemical resistive sensors, 139–44
  - textile applications, 144
- chemical vapour deposition (CVD), 56, 103–4
  - processes varieties, 105
  - sequence of events, 104
- chromogenic materials, 2
- circular knitting, 210–11
  - interlock and rib structure, 211
  - loop formation, 212
  - plain knitted structure, 210
- coaxial electrospinning, 6
- ‘Coke’ test, 462
- collaborative tagging *see* folksonomy
- commercialisation, 13–18
  - do-it-yourself (DIY), 15–18
  - system-oriented development and user needs, 13–15
- conducting polymer, 6, 56–7, 131, 132
- conductive fabrics, 54–8
- conductive fibres, 54–8
- conductive fillers, 142
- conductive nanocoatings, 101–10
  - future trends, 120
  - nanotechnology application, 110–19
  - overview, 101
  - smart textiles, 92–120

- conductive nanofibres, 92–101
  - future trends, 120
  - nanotechnology application, 110–19
  - overview, 92–3
  - smart textiles, 92–120
- Conductive Polymer Composites (CPC)
  - chemical resistive sensors, 140–3
    - application of textiles, 142–3
    - electrical resistivity of a poly(ethylene-co-ethacrylate)-carbon black (EEA-CB), 140
  - sensors material, 130–1
    - conductivity evolution, 131
  - temperature resistive sensors, 144–7
    - influence of filler content on the intensity of the PTC, 146
    - positive temperature coefficient (PTC) and negative temperature coefficient (NTC), 145
- conductive yarns, 54–8
- conductors, 34–6
- contacts, 237–8
  - electrical contact, 238
  - mechanical reliability, 246–7
    - cross section between a conductive thread and a contact pad on a woven e-stripe, 247
- ‘context-aware’ applications, 330
- ConText project, 425
- continuous fibres, 197–9
- conventional electrical current, 30
- copper, 38–9
  - textile-compatible copper, 39
- cotton, 192
- crimping, 297–8, 449
- cross-modality segmentation, 341
- crowd funding, 410
- Cute Circuit, 388
- cutting production, 53
- data rate, 332
- decision fusion, 346
- deletions, 355
- demonstrators, 238–46
- dipcoating, 57
- dispenser printing, 309
- disposable battery, 270–1
- distributed mode loudspeaker (DML), 261
- do-it-yourself (DIY), 15–18
  - interactive clothes, 17
  - solar shirt, 16
- double-wall nanotube (DWNT), 95
- drawframe, 194
- drift movement, 30
- drop casting, 57
- dry-spinning, 199
- dye-sensitised solar cells (DSSC), 323, 324
- E39 compression shirt, 436
- e-research, 18–20
- e-stripes, 232–6
  - bending radius vs. normalised resistance of copper layer, 234
  - contact areas, interconnect lines and bare die integrated circuit digital temperature sensors, 237
  - wet etching and lift-off process, 236
  - woven textiles and cracked metal layer after weaving, 233
- e-textile business models, 383–8
  - AIQ LED buttons and other components from the group, 388
  - Future-Shape’s Sensfloor, 387
  - vertical model supplier, 384–5, 388
  - vertical product supplier, 386
  - WarmX, 385
- elastic narrow fabric, 135
- electrical conductivity, 30–4
  - electrical potential, 31
  - quantities used in electronics around electric current, 34
  - surface resistivity measurement, 34
- electrical current, 30
- electrical inductance plethysmography, 423
- electrical percolation type mechanical sensors (EPTMS), 136–7
- electrical percolation type temperature sensors (EPTTS), 145
- electro-conductive materials, 30–6
  - carbon, 42–5
  - different materials and their resistivity, 35
  - future trends, 58
  - intrinsically conductive polymers (IPC), 45–7
  - metals, 37–42
    - ferrous materials, 37–8
    - non-ferrous materials, 38–42
  - processing into textile structures, 51–8
  - production technologies to obtain conductive textile structures, 51
  - properties, 36–7
    - stress–extension curves, 37
  - types and processing for smart textiles, 29–59
- electrocardiogram, 452, 460
- electrocardiography, 421, 424
- electrochemical deposition, 106–7
  - set-up, 106
- electrodermal activity (EDA), 452, 460
- electroencephalogram (EEG), 452
- electroless deposition, 54–5
- electroluminescence, 7
- electromagnetic compatibility (EMC), 302
- electromechanical coupling coefficients, 310
- electromyography (EMG), 421, 424
- electron beam evaporation, 235
- electronic circuit, 263–8
- electronic textiles, 156–62
- electronics, 7–11
  - flexible electronics, 8–9
  - large-area electronics, 8
  - miniaturisation, 7

- organic electronics, 8
- printable electronics, 9
- stretchable electronics, 10
- textile electronics, 10–11
- electroplating, 55
- electrospinning, 99
- electrostatic discharge (ESD), 302
- Elektrisola, 288
- ELITEX yarns, 450
- elongation resistive sensors, 133–9
  - change in electrical resistance of materials
    - affected by fillers disconnection, 136–8
  - elongation sensors made of CPC track and resistive response against elongation, 138
  - change in electrical resistance of materials
    - non-affected by fillers disconnection, 135–6
  - PANI fibre and resistance dependence against applied force, 137
  - change in electrical resistance of textile structures, 133–5
  - embroidering stretch sensor and measurement samples, 134
  - textile applications, 139
- embroidery, 218–24, 298
- energy harvesting technologies, 306–26
  - energy sources and storage, 307–8
  - fabrication processes, 308–9
  - kinetic energy harvesting, 309–15
    - cantilever piezoelectric vibration energy harvester, 312
    - coefficients of common piezoelectric materials, 311
    - fibre coated with ZnO nanowires, 313
    - notation of axis, 311
    - piezoelectric energy harvesters, 312–13
    - piezoelectric energy harvesting on fabrics, 313–15
    - piezoelectric theory, 309–12
  - solar energy harvesting, 323–6
    - coaxial photovoltaic fibre, 325
    - photovoltaic (PV) fabrics, 324–5
    - solar cell theory, 324
- thermoelectric energy harvesting, 315–23
  - body heat powered pulse oximeter, 318
  - ceramic thermoelectric module, 318
  - coiled-up TEG, 322
  - electrocardiography system integrated in a shirt, 319
  - planar dispenser printed TEG, 323
  - review of thermoelectric devices in smart fabrica applications, 318–23
  - Seebeck effect, 316
  - thermoelectric device structure, 317
  - thermoelectric properties evaluation, 317–18
  - thermoelectric theory, 315–17
- energy scavenging *see* energy harvesting technologies
  - EpoTek E4110, 297
  - EpoTek H20E, 297
  - etching, 235
  - EUR Eco-label, 393
  - Ewing, S., 376
  - Exmobaby garment, 436
  - EXO<sup>2</sup>/FabRoc heating system, 438
  - eyelets, 299
- fabric-based sensors, 427
- fabric sensors, 114–15
  - 3-D surface pressure mapping, 115
- Fast Multiple-Touch-Sensitive Input Device (FMTSID), 155
- fault detection, 349
- feature/sensor selection techniques, 350
- fibre capacitance, 164
- fibre colour, 78–81
  - changing effect under variable ambient illumination, 81
  - colour changing fibre, colour mixing and lit fibres, Plate II
  - solid colour plastic Bragg fibre, 79
- fibre drawing, 156–7
  - parameters effect, 169–70
- fibre length, 181–2
- fibre-optic sensing systems, 14
- fiducials, 303
- flat knitting, 212
- FLEXIBILITY project, 11
- flexible broadcast radio receiver, 275–6
- flexible electronics, 8–9, 229–8
  - contacts, 237–8
  - stripes fabrication, 232–6
  - technology principles, 229–32
    - bus system, 230
    - e-stripe with electronic device and integration of electronics into woven fabrics, 231
    - weaving, 236–7
- flexible flat loudspeaker, 261
- flexible graphite, 43
- flexible multilayer capacitors, 157
- flexible organic solar cell, 272–3
- flexible wireless data receiver tag, 276–7
  - simplified architecture for thin-film radio receiver, 276
- flexography, 265
- folksonomy, 19
- fragmentations, 355
- fully woven two-dimensional touch pad sensor
  - one-dimensional array of capacitance fibres, 183–6
    - cross-talk and channel calibration, 185–6
  - design and fabrication, 183–5
  - voltage response, 185
  - woven touchpad sensor, 184

- functionalising braids, 216–18
  - braided data cable with four electrical leads, 218
  - sensorised shroud lines in parachute, 217
- functionalising textiles, 222–4
  - embroidered contacts, 223
  - machine embroidered electrical contacts, 223
- functionalising woven fabrics, 206–8
  - textile circuit board, 207
- Future-Shape, 385
- Gerbing's Heated Clothing, 438
  - gestures, 340
- global energy, 20–2
  - Soft House, 21
- gold, 39–40
  - coated woven fabric through electroless deposition, 41
- graphite, 43
- gravure, 265
- hand-woven prototype, 82–4
  - launching light into a PBG fibre-based textile, Plate V
  - PBG Bragg fibre-based textile with a black silk matrix, Plate VI
  - PBG Bragg fibre-based textile with a white silk matrix, Plate IV
- healthcare smart textiles
  - wound healing functions, 115–17
    - modern wound dressings, 116
- hidden Markov models (HMM), 346
- human interface device (HID), 154
- humidity sensitive textile, 238–41
  - prototype, 240
  - sensor part of the e-stripe, 239
  - sensor response, 240
- inertial measurement units (IMU), 337
- Infineon, 285
- information acquisition system, 114–15
- information technology, 11–12
- infrared motion sensor, 269
- inkjet printing, 57–8, 308
- innovation, 377
  - management, 370, 376–82
    - creativity, 378–9
    - feasibility, 379–80
    - implementation, 380–1
    - key tasks, 378
    - market introduction and dissemination, 381
    - strategies, 381–2
    - strategies for small and medium enterprises, 382
    - terms and definitions, 377
- insertions, 355
- INSITEX, 451, 456
- insulating polymer, 132
- insulators, 34–6
- integration, 3
- Intellectual Property (IP) management, 370
- intelligent agent, 3
- intrinsically conducting polymer (ICP), 6–7, 45–7
  - chemical resistive sensors, 143
  - polypyrrole-coated para-aramid fibres, 46
  - sensors materials, 131–2
  - structures, 46
  - temperature resistive sensors, 147
- intrinsically conductive fibres, 52–4
- intrinsically conductive yarns, 52–4
- invention, 377
- isolated activity recognition, 341
- isotropic conductive adhesives (ICA), 296
- Jacquard loom, 84–5, 206
- joining technologies, 285–305
  - challenges for automated processes in electronic systems on textiles, 303–4
  - challenges for electronic systems on textiles, 302–3
  - conductive threads as electrical traces, 287–9
    - coax, 289
    - conductive threads selection, 288
    - double twisted yarn, 289
    - plain wire, 288–9
    - plated strips, 289
    - plated yarn, 289
    - stranded wires, 289
    - tinsel, 289
    - twisted yarn, 289
  - electrical connections protection, 301–2
    - welding spots between woven wires and FPC are protected by PU film, 301
  - electrical joining technologies overview, 291
  - electronic system components in textiles, 286–7
    - another approach to use of electronics in textiles, 287
    - assembled electrical circuit using various component package generations, 286
  - future trends, 304–5
  - introduction for electronics, 289–90
  - overview of existing technologies in the electronics and textile world, 290–9
    - bonding (using adhesives), 296–7
    - brazing, 293
    - conductive yarn crimping, 298
    - crimping, 297–8
    - electronic components bonded to a woven fabric substrate, 297
    - press snap, spring snap buttons and eyelets, 299
    - radiofrequency (RF) welding, 296
    - sewing and embroidery, 298
    - soldering, 290, 293

- TCB weld process, 295
- thermoccompression bonding (TCB), 293–5
- ultrasonic welding, 296
- Velcro, 298–9
- woven tinsel thread soldered to a PCB, 294
- woven wire weld onto a PCB, 295
- zippers, 299
- overview summary, 299–301
  - electrical connection sealed with hotmelts, 300
  - metallic buttons to connect electrical power, 300
  - textile joining technologies overview, 292
- Kelvin relationships, 317
- kinetic energy harvesting, 309–15
  - cantilever piezoelectric vibration energy harvester, 312
  - coefficients of common piezoelectric materials, 311
  - fibre coated with ZnO nanowires, 313
  - notation of axis, 311
  - piezoelectric energy harvesters, 312–13
  - piezoelectric energy harvesting on fabrics, 313–15
  - piezoelectric theory, 309–12
- Kirchhoff Current Law (KCL), 165
- Kirchhoff Voltage Law (KVL), 165
- ‘Klight’ project, 301
- knitting, 208–12
  - needle movement during loop formation, 209
  - sinker, 29
  - weft and warp classification, 208
- ‘leave-one-X-out’ cross-validation, 355
- Levitt, T., 377
- Lifeshirt, 435
- lift-off, 235
- line impedance, 287
- liquid crystal display (LCD), 8
- loudspeakers, 258, 261–3
  - printed PVDF loudspeaker, 262
  - printed TUC loudspeaker, 262
- Lurex yarn, 289
- macro- bending, 74–5
- macroelectronics, 8
- man-made fibres, 197–9
- market, 382–3
- market economics, 369–94
  - business models, 382–3
  - e-textile business models, 383–8
    - AIQ LED buttons and other components from the group, 388
    - Future-Shape’s Sensfloor, 387
    - vertical model supplier, 384–5, 388
    - vertical product supplier, 386
    - WarmX, 385
  - innovation management, 376–82
    - creativity, 378–9
    - feasibility, 379–80
    - implementation, 380–1
    - key tasks, 378
    - market introduction and dissemination, 381
    - strategies, 381–2
    - strategies for small and medium enterprises, 382
    - terms and definitions, 377
  - innovation management strategies, 370–82
  - intellectual property management, 375–6
  - major tasks of technology, innovation and IP management, 370
  - opportunities and challenges in e-textiles business, 388–93
  - e-textiles business drivers, 390–1
  - e-textiles market, 389–90
  - economics from production to retail, 392
  - regulations, certifications and markings, 392–3
  - smart-textiles terms and definitions, 388–9
  - technology push vs market pull, 391
  - textile and electronics businesses, 391–2
  - technology management, 371–5
    - forecasting and road mapping, 372–4
    - key tasks, 372
    - marketing, 374–5
    - organic photovoltaics roadmap, 373
    - projects implementation, 374
    - strategy, 372
    - terms and definitions, 371–2
- MARSAN smart glove, 430
- MDMO-PPV:PCBM, 324
- mechanical resistive sensors, 132–9
- medical applications, 420–39
  - body parameters monitoring, 421–32
    - blood oxygen saturation, 426–7
    - blood pressure, 425–6
    - body fluids composition, sweat analysis, 430–2
    - body movement, 427–9
    - breathing, 422–4
    - electrodermal activity (EDA), 429–30
    - heart activity, 424
    - microfluidic chip for sweat pH analysis, 431
    - muscle activity, 424–5
    - physiological signals that may be measured using textile based sensors, 422
    - post-stroke rehab garment, 428
    - respiratory monitoring shirt with integrated piezo-resistive sensors, 423
    - sweat rate sensor and humidity sensor, 432
  - challenges, 432–5
    - acceptance by medical profession, 434
    - ease of use, 433–4
    - ethics, 434–5
    - wearability, 432–3

- trends and applications, 435–9
  - Philips Lumalive ‘Woven electronics’ fabric platform, 439
  - three-dimensional image of knitted garment, 437
- melt spinning, 53–4, 197–9
  - plant component, 198
- metal-based filler, 130
- metal oxides, 48–9
  - ZnO-coated fibre surface through electroless deposition, 49
- Microflex EU FP7 project, 315
- MicroFlex project, 10
- Microwire technology, 438
- MONARCA project, 430
- moulded injection device (MID) technology, 304
- MP2-Jacket, 285
- MST4IT, 296
- multi-walled nanotube (MWNT), 94, 100
- Nano-Sphere, 408
- Nano-Tex, 408
- nanotechnology, 5–6, 487
  - application in smart textiles, 110–19
    - material functions and performances upgrade, 110–11
    - smart and intelligent textiles function development, 112–19
  - conductive polymer and composite films manufacturing, 96–101
    - conductive nanofibres with MWNT, 100
    - conductivity of nanofibre containing different MWNT, 101
    - electrospinning apparatus for nanofibre preparation, 99
    - nanofibre formation, 98
    - process to fabricate the MWNTs/PU composite, 98
- nanotextiles, 6
- natural fibres, 192–7
  - carding machine, 194
  - cotton plant with ripe cotton capsules, 193
- neutral polymer, 132
- nickel, 41–2
  - coated polyester fibres through electroless deposit, 42
- Nike+ products, 436
- Nitinol, 474
- non-conductive adhesives (NCA), 296
- Oekotex 100, 393
- offset printing, 265
- OFSETH, 423
- oligomeric semiconductors, 49
- Omron Wrist Blood Pressure Monitor, 425
- one-dimensional distributed touch sensor, 170–83
  - grounding of outer fibre and application of AC voltage to copper wire, 171
- time resolved response of a one-dimensional slide sensor, 183
- operational frequency, 182–3
- OPPORTUNITY, 356
- optical fibres
  - animated photonic bandgap (PBG) fibre using ambient and emitted light, 86
  - overview, 70–3
  - photonic bandgap (PBG) fibre, 76–82
  - photonic bandgap (PBG) fibre potential applications, 86–9
  - photonic bandgap (PBG) fibre reflective properties, 85
  - photonic textile manufacturing, 82–5
  - smart photonic textiles, 70–89
  - total internal reflection (TIR) fibre, 73–6
- organic and large-area electronic (OLAE) circuit design, 273–7
  - flexible technologies for textile integration, 258–73
    - components and demonstrators developed in FLEXIBILITY, 259–60
    - full value chain addressed in FLEXIBILITY, 261
  - overview, 253–8
    - applications, 254–8
    - stand-alone components and subsystems, 256–7
    - state-of-the-art progress, 257–8
  - packaging integration and service life issues, 279–80
  - technology for smart textiles, 253–84
  - textile integration, 277–9
- organic conductive filler, 130
- organic electronics, 8
- organic light-emitting diode (OLED), 7, 8, 9
- overfill, 355
- oxidised polymer, 131
- packaging integration, 279–80
- Panipol M, 321
- Paris, 400
- pattern recognition techniques, 330
- PEDOT:PSS, 324
- Peltier coefficient, 317
- Peltier Effect, 317
- Perkin, W. H., 400
- permittivity of the material, 310
- phase change materials (PCM), 471
- photonic bandgap (PBG) fibre, 76–82
  - animation using ambient and emitted light, 86
    - mixing reflection of the ambient light with emission of the guided light, Plate IX
  - colour changing effect under variable ambient illumination, 81
  - colourful PBG Bragg fibres, Plate I
  - light extraction, 77
  - potential applications, 86–9

- accents and novel lighting solutions, 86–7
- architectural lighting panel I with dynamic appearance, Plate XI
- Integration of the PBG fibres into paper for illumination, Plate XIV
- interactive garment with integrated silk, Plate XIII
- reconfigurable architectural lighting panel II, Plate XII
- strain sensing fabrics, 88–9
- swatches for wearable advertisement, Plate X
- textile appearance changes under night-time operation, Plate XV
- worker ware for low visibility conditions, 87–8
- red green blue yarns for dynamic colour manipulation, 82
- reflective properties under ambient illumination, 85
  - reflection of ambient light from PBG fibre-based textile, Plate VIII
- understanding colours, 78–81
- photonic crystal fibre (PCF), 72
- photonic textiles
  - animated photonic bandgap (PBG) fibre using ambient and emitted light, 86
  - manufacturing, 82–5
  - optical fibres, 70–89
  - overview, 70–3
  - photonic bandgap (PBG) fibre, 76–82
  - photonic bandgap (PBG) fibre potential applications, 86–9
  - photonic bandgap (PBG) fibre reflective properties, 85
  - total internal reflection (TIR) fibre, 73–6
- photoplethysmography (PPG), 426
- P3HT:PCBM, 324
- physical vapour deposition (PVD), 55, 103, 320–1
- Piezo-Force Microscopy (PFM), 314
- piezoceramic, 309
- piezoelectric materials, 2
- piezoelectric strain constant, 310
- piezoelectric vibration energy harvester, 312
- piezoelectric voltage constant, 311
- PLACE-it project, 11
- plain weave, 205
- plasma coating process, 309
- polymer
  - chemical resistive sensors, 139–44
  - mechanical resistive sensors, 132–9
  - resistive sensors for smart textiles, 129–48
  - temperature resistive sensors, 144–8
- polymer matrix
  - change by non-solvents, 141–2
  - change by solvents, 141
- polymer/nanoparticle composite, 98
- polymeric organic semiconductors, 49–51
  - TIPS-pentacene dip coated on a polyester filament surface, 51
- polymers, 6–7
- polyvinylidene fluoride (PVDF), 258, 261–2, 309
- positive temperature coefficient (PTC), 144–6
- Pouillet formula, 32–3
- press snap buttons, 299
- printable electronics, 9
- printed audio amplifier, 275
- printed infrared motion sensor, 256
- printed signal generator, 273–5
  - printed ring oscillator designed by TUC, 274
- printed technology, 263–5
  - printed three-dimensional integration approach of TUC, 266
- printed temperature sensor, 256
- printed thermoelectric devices, 321–2
- Profitex project, 217
- PSYCHE project, 430
- pulse oximetry, 426
- pulsed laser deposition, 107–9
  - schematic diagram, 108
- radio-frequency identification (RFID), 9
- radiofrequency (RF) welding, 296
- rapier technology, 203, 207
- RC ladder circuit, 163
- RC ladder network model, 163–5, 173–81
  - capacitor fibre covered with foil probe, 163
  - experimental data vs. theoretical model, 178–81
    - fibre response to the touch of equivalent human probe, 179
  - one-dimensional slide sensor, 177
  - stand-alone capacitor fibre, 175
- reactive ion etching (RIE), 320
- rechargeable battery, 271–2
  - printed battery integration approach, 272
- recognition accuracy, 354–5
- red green blue (RGB), 75
  - yarns for dynamic colour manipulation, 82
- red green blue (RGB) yarns
  - dynamic colour manipulation, 82
    - form of a braid of three fibres and color-on-demand textile set-up, Plate III
- reduced polymer, 132
- resistance welding, 293
- resistive pressure sensors, 139
- resistive sensors
  - chemical resistive sensors, 139–44
  - future trends, 148
  - mechanical resistive sensors, 132–9
  - overview, 129–32
    - general sensing principles, 132
  - polymer for smart textiles, 129–48
  - temperature resistive sensors, 144–8



- Restriction of Hazardous Substances Directive (RoHS), 293
- ring spinning, 194–5
  - position, 195
  - ring and traveller, 195
- Rohner, F., 377
- rotor spinning, 195–6
  - principle, 196
- sample, 332
- sample rate, 332
- sampling interval, 332
- scratching, 74–5
- screen printing, 57, 308
- SeatSen project, 461
- Seebeck coefficient, 316
- Seebeck Effect, 315–16
- Seebeck Voltage, 316
- 'segmentation' algorithm, 341
- SEIKO Corporation, 320
- Seiko Thermic watches, 320
- self-assembly nanocoating, 109–10
  - covalent layer-by-layer assembly of functional particles, 110
- self-cleaning textiles, 117–19
  - degradation result of wine stain and a concentrated coffee stain, 118
- self-heating textiles, 117–19
  - thermal images and temperature changes, 119
- self-repairing textiles, 117–19
- semiconducting materials, 30–6
  - different materials and their resistivity, 35
  - future trends, 58
  - processing into textile structures, 51–8
    - production technologies to obtain conductive textile structures, 51
  - properties, 47–51
  - types and processing for smart textiles, 29–59
- semiconductive fabrics, 54–8
- semiconductive fibres, 54–8
- semiconductive yarns, 54–8
- semiconductors, 34–6
- SensFloor mats, 385
- sensor, 332
- sensor security tag system, 256
  - architecture and application, 257
- sewing, 298
- shape memory materials, 2
- short organic semiconductors, 49–51
  - structures, 50
    - TIPS-pentacene dip coated on a polyester filament surface, 51
- shuttle technology, 203, 207
- signal processing technologies, 329–57
  - activity-aware applications, 331–2
  - activity recognition principles, 339–41
    - human activities, 339–41
  - recognition system, 341
  - experimental aspects, 351–6
    - activity labelling approach, 353
    - activity recognition performance metrics, 354
    - data recording and ground truth annotation, 351–3
    - performance evaluation, 353–5
    - technical implementation, networking and prototyping, 355–6
  - from on-body sensing to smart assistants, 329–31
    - prototype representation of typical 'wearable computing' system, 330
  - future trends, 356–7
  - sensing principles for activity recognition, 332–9
    - benefits of smart textiles for activity awareness, 334–5
    - challenges of textile sensing, 335–7
    - motion artefact in the 'drink' gesture, 336
    - on-body accelerometer signals, 333
    - sensing requirements, 334
    - sensor modalities, 337–9
    - sensor modalities for activity-aware systems, 338
  - signal processing and pattern analysis, 342–51
    - addressing the challenges of smart textiles, 349–51
    - classification, 346
    - decision fusion, 346
    - feature extraction, 345
    - four activities of car assembly scenario, 348
    - method and parameter selection, 346–9
    - null-class rejection, 346
    - processing steps used to infer activities from on-body sensors, 343
    - segmentation, 345
    - sensor data acquisition, 344
    - signal pre-processing, 344
- signal quality appraisal, 350
- silicon, 48
- silver, 39
  - textile compatible silver, 40
- single capacitor fibre
  - electrical response, 171–3
    - one-dimensional slide sensor, 172
  - voltage distribution along the outer fibre electrode, 173
  - voltage measurement, 174
- single-fibre touch sensor, 181
- single-walled nanotube (SWNT), 94
- smart fabrics and interactive textiles (SFIT), 389
- smart object, 2
- Smart Rope project, 216
- Smart Shirt, 304, 436
- smart-textile sensing, 331, 334

- smart textiles, 1–22
  - architectural applications, 468–87
    - architectural applications, 472–81
    - future trends, 481–7
    - key themes in modern architecture, 468–70
    - smart materials, 470–2
  - automotive applications, 444–66
    - electric vehicles impact on smart textiles
      - applications, 463–5
      - future trends, 465–6
    - key safety and quality requirements, 461–2
    - prototypes in vehicles, 450–61
    - smart-textile applications and their
      - potential for use in cars, 449–50
    - textiles in vehicles, 445–9
  - commercialisation approaches, 13–18
  - conductive nanofibres and nanocoatings, 92–120
    - future trends, 120
    - nanotechnology application, 110–19
  - electro-conductive and semiconducting
    - materials types and processing, 29–59
  - carbon, 42–5
  - future trends, 58
  - intrinsically conductive polymers (IPC), 45–7
  - metals, 37–42
  - processing into textile structures, 51–8
  - properties of electro-conductive materials, 36–7
  - semiconducting materials properties, 47–51
- fabrication technology for thin-film
  - electronics integration, 227–49
    - contacts mechanical reliability, 246–7
    - demonstrators, 238–46
    - flexible electronics, 229–38
    - future trends, 247–9
    - overview, 227–9
- future trends, 18–22
- joining technologies, 285–305
  - challenges for automated processes in
    - electronic systems on textiles, 303–4
  - challenges for electronic systems on
    - textiles, 302–3
  - conductive threads as electrical traces, 287–9
  - electrical connections protection, 301–2
  - electronic system components in textiles, 286–7
  - future trends, 304–5
  - introduction for electronics, 289–90
  - overview of existing technologies in the
    - electronics and textile world, 290–9
  - summary to joining technology overview, 299–301
- kinetic, thermoelectric and solar energy
  - harvesting technologies, 306–26
  - energy sources and storage, 307–8
  - fabrication processes, 308–9
  - kinetic energy harvesting, 309–15
  - solar energy harvesting, 323–6
  - thermoelectric energy harvesting, 315–23
- medical applications, 420–39
  - body parameters monitoring, 421–32
  - challenges, 432–5
  - trends and applications, 435–9
- new enabling technologies, 5–13
  - consequences and impact, 12–13
- optical fibres, 70–89
  - animated photonic bandgap (PBG) fibre
    - using ambient and emitted light, 86
  - overview, 70–3
  - photonic bandgap (PBG) fibre, 76–82
  - photonic bandgap (PBG) fibre potential
    - applications, 86–9
  - photonic bandgap (PBG) fibre reflective
    - properties, 85
  - photonic textile manufacturing, 82–5
  - total internal reflection (TIR) fibre, 73–6
- organic and large-area electronic (OLAE)
  - technology, 253–84
  - circuit design, 273–7
  - flexible technologies for textile integration, 258–73
  - overview, 253–8
  - packaging integration and service life
    - issues, 279–80
  - textile integration, 277–9
- polymer-based resistive sensors, 129–48
  - chemical resistive sensors, 139–44
  - future trends, 148
  - mechanical resistive sensors, 132–9
  - overview, 129–32
  - temperature resistive sensors, 144–8
- production challenges, 224–5
- sustainability improvement, 399–416
  - design general guidelines, 416
  - product durability, 407–10
  - recycling, 403–7
  - sustainable design approach, 411–15
  - sustainable production, 401–3
- technological trade-off between smartness
  - and integration, 2–5
- technology management and innovation
  - strategies, 369–94
  - business models, 382–8
  - innovation management strategies, 370–82
  - opportunities and challenges in e-textiles
    - business, 388–93
- SmartLife HealthVest, 436
- social networks, 18–19
- soft capacitor fibres
  - capacitive sensing, 154–5
  - electrical characterisation, 162–70
    - capacitor fibre fabrication and electrical
      - characterisation, 161
    - capacitor fibre length effect, 166–8
    - effective capacitance and resistance vs.
      - frequency, 166

- fibre drawing parameters, 169–70
  - frequency dependent response, 165–6
  - measurement set-up, 162
  - operation temperature effect, 168
  - operation temperature effect on electrical properties, 168
  - RC ladder network model, 163–5
- electronic textiles, 156–62
  - connections and potential applications, 159–62
  - cylindrical capacitor fibre and rectangular PMMA tube, 158
  - designs, 158–9, 160
  - materials and fabrication, 156–7
- fully woven two-dimensional touch pad sensor, 183–6
- one-dimensional distributed touch sensor, 170–83
- touch-sensitive smart textiles, 154–86
- solar energy harvesting, 323–6
  - coaxial photovoltaic fibre, 325
  - photovoltaic (PV) fabrics, 324–5
  - solar cell theory, 324
- soldering, 290, 293
- solution polymerisation, 56–7
- solution spinning, 199
  - process, 200
- sphygmomanometer, 425
- spin coating, 57, 235
- spring snap buttons, 299
- sputtering, 235
- stainless steel, 37–8
  - yarns forms, 38
- standard embroidery, 218–21
  - capsule containing the bottom thread spool, 220
  - double lock stitch, 219
  - embroidered conductive lines, 220
  - embroidery machine elements, 219
- staple fibre spinning, 193–4, 199
- staple fibres, 192
- STELLA project, 11
- stethoscope, 425
- strain sensing fabrics, 88–9
  - stretching of plastic Bragg fibres, Plate XVI
- Stretchable Circuits, 301
- stretchable electronics, 10
- surface polymerisation, 111
- sustainability, 468
  - closing the loop, 402–3
    - eliminating waste, 403
    - minimising waste, 402
  - design general guidelines, 416
  - improvement in smart textiles, 399–416
    - creating a sustainable future, 400–1
    - sustainability paradox, 400
  - initial design, 411–14
    - electroluminescent material or LEDs
      - simple panel, 414
    - engage, 414
  - fabric mask, 414
  - inspire, 412
  - involve, 412–13
  - methods for user involvement, 413
  - motivate, 413–14
  - understanding, 411–12
- product development, 414–15
  - electronic hardware inside a tent pole, 415
  - material, 414–15
  - production, 415
- product durability, 407–10
  - feel good fabrics, 408–9
  - improving durability, 409
  - textile durability, 408
  - user involved design, 409–10
  - user involvement in each stage of the design process, 410
- recycling, 403–7
  - conductive textile materials, 406
  - smart object built inside the button of a shirt, 405
  - smart-textile recycling, 404–5, 407
  - textile recycling, 403–4
  - watch-pocket on a pair of Levi's jeans, 404
- smart-textiles sustainable production, 401–3
  - transparency, 402
- sustainable design approach, 411–15
- textile care, 407–8
  - cleaning, 408
  - ironing, 408
- sweat, 430
- system provider, 14
- tailored fibre placement (TFP), 221–2
  - electrical wire application, 222
  - embroidery with carbon fibres and electrical wire applied to a textile substrate, 222
  - method, 221
- Tarde, G., 377
- technological trade-off, 3–5
  - energy curtain, 4
- technology, 371
- technology management, 370, 371–5
  - forecasting and road mapping, 372–4
  - key tasks, 372
  - marketing, 374–5
  - organic photovoltaics roadmap, 373
  - projects implementation, 374
  - strategy, 372
  - terms and definitions, 371–2
- technology marketing, 375
- temperature resistive sensors, 144–8
  - textile applications, 147–8
- temperature sensitive textile, 238–41
  - prototype, 240
  - sensor part of the e-stripe, 239
  - sensor response, 240

- temperature sensor, 269
- textile electronics, 10–11
- textile fabrication
  - embroidery, 218–24
  - fabric production, 202–8, 208–12, 213–18
  - fibre and yarn production process, 192–7, 197–9
  - fibres and yarns functionalisation, 199–202
    - electrically conductive material wound around a core yarn, 201
    - silver-coated polyamide fibres, 202
  - overview, 191–2
    - fibre material classification, 192
    - processes, 191
  - smart-textile production challenges, 224–5
  - technology for embedding electronics into fibres, yarns and fabrics, 191–225
- textile finishing, 110–11
- textile innovation, 377
- textile integrated bus system, 241–3
  - prototype, 242
- textile integrated matrix, 243–6
  - flexible stripe with contact pads and stripe indication, 244
  - prototype, 245
  - thin-film transistor, 245
- textile integration, 277–9
  - methodology, 279
  - state-of-the-art, 278
- textile prototype
  - fabricated with a Jacquard loom, 84–5
  - leaf pattern made of cotton thread and PBG fibre, Plate VII
- Textronics, Inc., 376
- thermocompression bonding (TCB), 293–5
- thermoelectric energy harvesting, 315–23
  - ceramic thermoelectric module, 318
  - review of thermoelectric devices in smart fabric applications, 318–23
    - body heat powered pulse oximeter, 319
    - coiled-up TEG, 322
    - electrocardiography system integrated in a shirt, 319
    - micro thermoelectric generators, 320–1
    - planar dispenser printed TEG, 323
    - printed thermoelectric devices, 321–2
    - thermoelectric generators (TEGS) human applications, 318–21
- Seebeck effect, 316
- thermoelectric device structure, 317
- thermoelectric properties evaluation, 317–18
- thermoelectric theory, 315–17
- thermoelectric generators (TEGS), 318–21
- thin-film electronics
  - contacts mechanical reliability, 246–7
  - demonstrators, 238–46
  - fabrication technology for integration into smart textiles, 227–49
  - flexible electronics, 229–38
    - future trends, 247–9
      - large scale production, 248
      - user acceptance, 248–9
      - washability, 248
    - overview, 227–9
      - smash shirt, 228
- thin-film technology, 8, 265–8
  - bendable IGZO thin-film transistor technology, 267
  - bending machine for testing, 268
  - IGZO thin-film field-effect-transistor performance, 268
- thin-film transistor (TFT), 265
- Thomson coefficient, 317
- Thomson Effect, 317
- three-thread system *see* tailored fibre placement (TFP)
- total internal reflection (TIR), 72
- total internal reflection (TIR) fibre, 73–6
  - dynamic colour manipulation, 75–6
  - schematic diagram, 76
  - light extraction, 74–5
    - microbending and surface corrugation, 75
- touch screen, 270–3
- touch-sensitive smart textiles
  - soft capacitor fibres, 154–86
    - capacitive sensing, 154–5
    - capacitor fibre as one-dimensional distributed touch sensor, 170–83
  - electrical characterisation of isolated capacitor fibre, 162–70
  - electronic textiles, 156–62
  - fully woven two-dimensional touch pad sensor, 183–6
- Trott, P., 377
- twill weave, 205
- twisting, 200
- two-thread system *see* standard embroidery
- ultrasonic welding, 296
- underfill, 355
- vapour deposition, 102–4
  - functionally graded multilayer coating design, 103
  - property requirements in different zones of a coated surface, 102
- Velcro, 298–9
- VIZIO, Inc., 372
- WarmX, 384
- warp knitting, 212–13
  - structure, 213
- wearable electronics, 389
- wearable energy storage, 112–14
  - gold-coated plastic wire covered with ZnO nanowires arrays, 113
- wearable solar cell, 112–14
  - gold-coated plastic wire covered with ZnO nanowires arrays, 113

- weaving, 202–8, 236–7
  - airjet weaving loom, 205
  - basic principle, 203
  - closed fabric rim, 204
  - functionalising woven fabrics, 206–8
  - rapier/gripper, 204
  - weave patterns, 205–6
    - Jacquard weaving loom, 206
    - plain, twill and atlas weave, 205
- Web 2.0, 18–20
- wet spinning, 54, 199
- white coat hypertension, 426
- Wikis, 18
- winding, 200
- wire drawing, 52
- wireless audio data streaming tag system
  - architecture of system enabling wireless streaming, 256
- Zimmermann, J., 377
- zinc oxide (ZnO), 309
- zinc oxide (ZnO) nanowires, 313
- zippers, 299