Electronic Supplementary Information

ibres — Threads of Intelligence — Enable A New Generation of Wearable Systems

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Table 1. Summary of representative functional fibres enabled smart fabrics from acting fibres, active materials, working mechanisms, fabrication technologies, and applications

Acting fibres	Active materials	Working mechanisms	Fabrication technologies	Applications	Refs
Semiconducting nanowire-based fibres	Se	Photoelectricity	Thermal-drawing combined with sonochemical treatment	Fluorescence imaging system	[1]
Small-core single-crystal germanium fibres	Ge	Photoelectricity	Chemical vapor deposition	Photodetection at telecommunication wavelength	[2]
Glass-clad semiconductor core fibres	SeTe	Photoelectricity	Reactive molten core approach	Optical switch	[3]
Metal-insulator-semiconductor fibres	As2Se3	Photoelectricity	Thermal-drawing	Photodetector array fabric	[4]
Polymeric geometric fibres	As40Se49Te11Sn5	Photoelectricity	Thermal-drawing	Omnidirectional web photodetector fabrics	[5]
Non-centrosymmetric fibres	P(VDF-TrFE)	Piezoelectricity	Thermal-drawing	Acoustic wave detector fabrics	[6]

Composite piezoelectric fibres	BTO/P(VDF-TrFE)	Piezoelectricity	Thermal-drawing	Audible microphone fabrics	[7]
Composite piezoelectric fibres	BaTiO3/PVDF	Piezoelectricity	Electrospinning	Distinguish vocal patterns	[8]
Piezoelectric nanofibres	BaTiO3/PVDF	Piezoelectricity	Coating	Active voice recognition	[9]
Core-sheath conductive fibres	GO-CNT	Piezoresistivity	Coating and chemical reduction	Tactile-tension sensory fabrics	[10]
Soft and stretcable fibres	Liquid metal	Piezoresistivity	Thermal-drawing	Probes of multimodal deformations	[11]
Coaxial piezoresistive fibres	Stainless-steel	Piezoresistivity	Coating	AI-powered conformal tactile fabrics	[12]
\	PEDOT:PSS	Piezoresistivity	Chemical vapor deposition	Respiratory sensor fabrics	[13]
Liquid metal fibres	Liquid metal	Piezoresistivity	Syringe injection	Electronic fabrics systems with near-field powering and communication	[14]
Low viscosity polymer fibres	Liquid metal	Piezoelectricity	Soluble-core thermal drawing	self-adapting multi-dimensional sensory fabrics	[15]
Twisted MWCNT fibres	MCNTs	Electromechanic actuation	Dry spining and chemical vapor deposition	Artificial muscles	[16]

Cellulose yarns coated with PPy	PPy	Electromechanic actuation	Metal-free deposition	Artificial muscles	[17]
Twisted CNT fibres	CNTs	Vapor actuation	Hierarchical and helical assembly	Actuating fabrics	[18]
Triacetate-cellulose bimorph fibres	CNTs	Infrared gating actuation	Coating	Thermal management fabrics	[19]
Coiled monofilament fibres	Nylon	Thermomechanical actuation	Twist insertion	Artificial muscles	[20]
Conductive weft and luminescent warp fibres	Ionogels, ZnS phosphor, and Ag	Electroluminescence	Melt-spinning and coating	Large-area display communication fabrics	[21]
Diode fibres	Si	Photoelectricity	Thermal-drawing	Optical communication fabrics	[22]
\	Ag conductor ink, CNTs	Piezoresistivity	Stencil printing and coating	Wireless body area sensor fabrics	[23]
\	Cu/Ni	Piezoresistivity	Laser-cut	Radio surface plasmons mode communication fabrics	[24]
\	Cu/Al	\	Stacking	Near-field communication	[25]

				fabrics	
Interlaced cathode and anode fibres	Ti, ZnO, and PEDOT:PSS	Photoelectricity	Dip-coating	Polymer solar cell fabrics	[26]
Photoanode fibres	ZnO, Mn,	Photoelectricity	In-suit growth	Photo-rechargeable fabric	[27]
Double-twisted perovskite fibres	CH3NH3PbI3-xClx, P3HT, CNTs, TiO2, and Ag	Photoelectricity	Dip-coating	Wearable fibrous perovskite solar cell	[28]
Polyvinyl chloride/ BaTiO3 fibres	BaTiO3	Piezoelectricity	Wet-spinning	Piezoelectric nanogenerator fabrics	[29]
Twisted stainless steel/polyester fibres	Stainless steel, polyester, and PDMS	Triboelectricity	Coating and stacking	Triboelectric nanogenerator fabrics	[30]
Neodymium magnet fibres	NdFeB, Cu coils	Electromagnetics	Blow spinning	Magnetoelectrical generator fabrics	[31]
Continuous p/n thermoelectric fibres	CNTs, PEI, PVA	Thermoelectricity	Gelation extrusion	Modularized thermoelectric generator fabrics	[32]

CNT fibres	CNTs	Thermoelectricity	Wet-spinning	Thermoelectric generator fabrics	[33]
Lithium-ion battery fibres	Cu, Al, LCO, and graphite	Electrochemistry	Dip-coating	Fibre lithium-ion batterie fabrics	[34]
Lithium-air battery fibres	CNTs, LiI	Electrochemistry	Wrapping	Lithium-air battery fabrics	[35]
Zinc ion fibres	Zn, MnO2, GO	Electrochemistry	Soaking and coating	Wireless body area network fabrics	[36]
\	Ag, polyethylene	Nanophotonic heating	Coating and plating	Radiative heating fabrics	[37]
\	Ag	Joule heating	Coating	Thermal management fabrics	[38]
\	MXene	Joule heating and solar heating	Coating	Passive and active heating fabrics	[39]
\	ZnO, polyethylene	Spectrally selective cooling	Coating	Radiative cooling fabrics	[40]
Metafibers	TiO_2, PLA	Extended spectra response cooling	Melt-spinning	Passive daytime radiative cooling fabrics	[41]
Thermally conductive fibres	boron nitride, PVA	Thermal conduction	3D printing	Thermal regulation fabrics	[42]
light-emitting electrochemical cell fibres	CNTs, ZnO	Electrochemistry	Wrapping	Colour-tunable fabrics	[43]

Transparent conductive fibres	ZnS, Cu, and Au	Electroluminescence	Coating and solution-based metallization	Display patterns changable fabrics	[44]
Stretchable and conductive coaxial fibres	MXene	Triboelectricity	Wet-spinning	Strain sensing fabrics for body motion detection	[45]
\	Ag	Triboelectricity	Coating	Wireless sensory fabrics for pulse detection	[46]
\	Bismuth oxide	Piezoresistivity	Coating	Flexible breath sensory farics for nephropathy Diagnosis	[47]
CNT fibres	CNTs, Prussian blue, PEDOT:PSS, PAIN, and Ag	Electrochemistry	Electrospining and coating	Electrochemical fabrics for monitoring health conditions of human body	[48]
\	CNTs, Ni	Piezoresistivity	Stacking	Tactile sensory fabircs for keyboard control	[49]
Conductive hierarchical hairy fibres	Ag	Piezoresistivity	Coating	Multimodal gesture distinguishable fabrics for computer control	[50]
Kelver fibres	Ag	Capacitance	Chemical reduction	Pressure sensory	[51]

				fabrics for drone quadrotor control	
Digital fibres	Chips	\	Thermally drawing	machine-learning inference fabrics	[52]
Ag fibres	Ag, P(VDF-TrFE), Au, Pentacene	Piezoelectricity	Dip-coating	Neural network fabrics for processing electrocardiogram data	[53]

Table S2. Comparison of thermoelectric properties of semiconductors-based thermoelectric fibres and fabrics.

Semiconductors	Type	Heat sink	p-n pairs	Electronic connection	ΔT (°C)	Area (mm^2)	S2σ ($\mu Wm^{-1}K^{-2}$)	κ($Wm^{-1}K^{-1}$)	ZT	Output Voltage (mV)	Output Power (μW)	Reference
Ag_2Te	n-type	/	/	/	Up to 40	100	359.76	/	/	0.52	/	[54]
$Bi_{0.5}Sb_{1.5}Te_3$ (p type) and $Bi_2Te_{2.7}Se_{0.3}$ (n type)	Both	/	Constructed uni-couples	Sintered fibers and metallic contacts	12	0.0314	170-260	/	/	4.8	0.018	[55]
Si NWs	Both	/	Arrays connected in series	Metal lines	-203.15	25	0.047	9	0.047	27.9	0.47	[56]
Boron-doped Si nanotube	p-type	\	\	Metal contacts with Mo pads	40-700	5000	/	0.015	0.34	22	/	[57]

$Bi_{0.5}Sb_{1.5}Te_3$ (p type) and Bi_2Se_3 (n type)	Both	Copper	Arrays connected in series	/	-213.15	/	3.52	0.844	1.25	97	/	[58]
$Bi_2Te_{2.7}Se_{0.3}$ (n type) and $Bi_{0.5}Sb_{1.5}Te_3$ (p type)	Both	/	Arrays connected in series	/	/	100	183	0.77	/	0.83	0.81	[59]
PbTe nanocrystals	p-type	/	/	Coated on Glass Fibers	58	/	150-410	0.228-0.226	0.2-0.73	1.7	/	[60]
CNT	p-type	/	/	AFM probe with local heating	155	/	/	/	/	/	/	[61]
Sb_2Te_3 (p-type) and Bi_2Te_3 (n-type)	Both	/	Arrays connected in series	Silver foil	5-35	/	/	/	/	10	15	[62]
Bi_2Te_3 (n-type) and Sb_2Te_3 (p-type)	Both	/	Arrays connected in series	Silver paste	50	160	/	1.48	/	90	/	[63]
SWCNTs/Sb_2Te_3 hybrid films (p-type)	Both	/	Arrays connected	Vacuum filtration	70	/	108	/	0.0035	135	23.6	[64]

and RGO/Bi_2Te_3 hybrid films (n-type)			in series	and annealing								
PEDOT /Cu_2Se NWs	n-type	/	/	/	30	/	270.3	0.25-0.3	0.3	15	320	[65]
PVDF/Ta_4SiTe_4 whiskers	n-type	/	/	/	35.5	/	576	1.7	0.13	60	1680	[66]
PEDOT /Te NWs	p-type	/	/	Wet-spinning and silver paste	40	/	78.1	0.5-1	0.2	31	0.197	[67]
PANI/SWNT/Te Nanocomposite	p-type	/	/	Drop-casting and silver adhesive	40	/	101	0.2-0.4	/	100	/	[68]
P3HT	p-type	/	/	Drop-casting and doping with $Fe(TFSI)_3$	40	/	62.4	0.23	0.1	100	/	[69]
PANI	p-type	/	/		Varies	/	Varies	0.2-0.4	2.75×10^{-5}	/	/	[70]

PEDOT globular nanoparticles	p-type	/	/	/	/	/	18.8	0.1-0.5	0.0188	/	/	[71]
PEDOT nanowires	p-type	/	/	Spin-coating, treated with EG	/	/	102.7	0.258	0.09	/	/	[72]
PEDOT:PSS (p-type) and Ni wires (n-type)	Both	/	Arrays connected in series	Wet-spinning followed by H_2SO_4 treatment	-263	0.0315	147.8	0.5-1	0.05-0.09	0.72	0.00051	[73]
P3HT-DWCNT	p-type	/	/	/	20	300	176	2	0.0069	33.5	0.0145	[74]
rGO/PEDOT /TeNW hybrid (p-type) and TeNWs (n-type)	Both	/	Arrays connected in series	/	50	200	143	0.21	0.21	58	/	[75]
Bi_2Te_3 nanowire-PEDOT hybrid	n-type	/	/	Nanowire-embedded nanofilm	60	400	7.45	0.047	0.048	69.5	130	[76]

				network								
Bi_2Te_3 coated PAN	n-type	/	/	/	200	400	/	12	0.07	45.2	1.01	[77]
PEDOT:PSS	p-type	/	/	Series connection with silver wires	75.2	400	0.045	0.12	9.5×10^{-5}	4.3	0.00125	[78]
PEDOT:PSS	p-type	/	/	Series connection with Ni foils	48.5	35	45	0.1	0.0013	75.2	/	[79]

Table S3. Summary of fabrications strategies and their commonly used materials, advantages and disadvantages

Fabrication strategies	Materials	Working mechanisms	Advantages	Disadvantages
Wet spinning	Graphene[80], carbon nanotube[81], MXene[82], PEDOT:PSS[83], polyarylonitrile[84], alcohol silk[85], chitosan[86], cellulose[87], and thier composites[88, 89]	Phase separation induced by solvent exchange	High yeild; Low cost; Mild condition; Wide manufacture range for raw materials; Easy control of fibre diameter	Tedious Post-spining process; Fibre diameter is limited to microscale; Washing to remove imputities
Dry spinning	Graphene[90], carbon nanotube[91], polyimide[92], polyamic acid[93], poly (lactic acid)[94], ceramic[95], Au nanowires[96], chitin[97], silk[98], gelatin[99], cellulose nanocrystal[100], and thier composites[101]	Evaporation and solidification of the spinning solution.	High spning speed; Whiout washing to remove imputities; Opeation is simple; Applying to heat-sensitive polymers	Flammble solvent hazards; Solvent recovery is needed; Difficult to precisely control section structure of fibres; High heat input
Electro spinning	Carbon nanotube[102], graphene oxide[103], MXene[104], polyurethane[105], polyacrylonitrile[106], polyethylene oxide[107], polyimide[108], polyethylene glycol[109], polyvinyl alcohol[110], polyvinylidenefluoride[111], polyvinylidene fluoride-trifluoroethylene nylon[112], collagen[113], chitosan[114], cellulose nanocrystal[115], silk fabroin[116], peptide[117], and thier composites[115, 118-120]	Electric field enables migration of charged polymers into nanometer-scale fibre	Production of nanoscale fibres; Wide selection of materials; Control over porosity and morphology;	High voltage used; Presence of the volatile solvent; Poor mechnical performances; Low precison in fibre deposition Low biocompatibility

Blow spinning	Graphene[121], carbon nanotube[122], poly(ε-caprolactone)[123], polystyrene[124], polyvinyl alcohol[125], poly(vinylidene fluoride)[126], poly(vinylidene fluoride-co-hexafluoropropylene)[127], polylactic acid[128], polyamic acid[129], polyacrylonitrile[130], nylon[131], carboxymethyl cellulose[132], cellulose acetate[133], and their composites[134, 135]	High-velocity air stream greatly stretchs the extruded polymer solution	High Production Speed; Production ultrafine fibres; Low energy comsumption; Versatile materials selection; High yield	Limited fibre strength; Low preparation precision; Limited dimensional accuracy; An inability to construct 3D configurations; Complex equipment
Rotary jet spinning	Poly(lactic acid)[136], poly(ethylene oxide)[137], poly(acrylic acid)[138], polycaprolactone[139], gelatin[140], and their composites[139, 141]	Extrusion and elongation of polymer solutions into nanofibers under centrifugal force	Creation of fine structures and hierarchies of fibres; Control oover fibre arrangements in three dimensions; Rapid Production; Less solvent requires;	Complex equipment; Low fibre length; High operation cost; High energy consumption

Melt spinning	Poly(lactic acid)[142], polyurethane[143], polyvinyl alcohol[144], poly(vinylidene fluoride)[145], polyethylene terephthalate[146], polyethylene[147], polybutylene terephthalate[148], polyamide[149], polycaprolactone[150], poly(lactic acid)/$BaTiO_3$[151], polyaniline/polypropylene[152]	Rapid cooling processes induced the solidification of molten polymer solutions	High production speed; Wide selection of thermpplastic polymers; Whithout using solvents; Uniform fibre diameter	Limited to thermoplastic materials; Low heat resistance of fibres; Substantial heat energy requires; Complex and costly equipment
Thermal drawing	Styrene-ethylene-butylene-styrene[15], carbon-black-loaded polyethylene[153], poly(vinylidene fluoride)[154], poly(vinylidene fluoride-co-hexafluoropropylene)[155], chalcogenide semiconductors (Sn, As-Se-Te-Sn, As-Se-Te),[156] Se nanowires,[1] Piezo-ceramics ($PbTiO_3$ and $BaTiO_3$),[7] liquid metal,[157] lithium-iron-phosphate,[158] lithium bis(trifluoromethane sulfonimide)[159]	Viscous flow phenomenon induced by the material's softening at high temperatures	High yield; Customization; Versatile materials selection; Cost-effictive; Sophisticated structures	High heat energy input; Limited to thermoplastic polymers; Equipment complexity; Front design of preforms

Dip coating	Graphene[160], graphene oxide[161], carbon nanotube[162], liquid metal[163], PEDOT:PSS[164], polyaniline[165], polypyrrole[166], Ag or Au nanoparticles or nanowires,[167, 168] MXene[169]	Evaporation of solvents enables formation of functional layers	Simple process; A variety of materials selection; Control over coating thickness; Adaptable for different types of fibres	Time-consuming drying; Poor reproducibility; Specialized equipment; Solvent hazards
Electrospray coating	Carbon nanotube[170], graphene oxide[171], MXene[172], Ag nanowires[173], PEDOT:PSS[174], polyaniline[175], polycaprolactone[176], silk[177]	Applied electric field induces Coulombic fission of liquid droplets	Production of fine fibres; High surface area of fibres; Control over fibre's diameter, aligment, and porosity	Complex equipment; Low production rate; Limited to scale production; Poor uniformity
Compression coating	Graphene[178], MXene[179]	Application of pressure to force coating materials onto fibrous substrates	Adhesion enhancement; Fast an efficient process; Low materials wastage	Limited coating materials; Specialized fibre substrate; Difficult to control coating thickness
Screen printing	Carbon nanotube[180], graphene[181], graphene oxide[182], MXene[183], Ag nanoparticles or nanowires[184]	Use of pressure to allow ink to pass through the open areas onto the fabric surface	High durability; Large-scale production; Custom design	Limited inks; Inapplicable to intricate designs; Limited color range; Low stretchability and breathability of fibres

3D printing	Graphene[185], carbon nanotube[186], liquid metal[187], PEDOT:PSS[188], MXene[189], boron nitride[190], poly(vinylidene fluoride)[191], poly(vinyl alcohol)[192], thermoplastic polyurethane[193], silk fibroin[194], cellulose nanofibril[195]	Layer-by-layer assembly coupled with digital design	Complex geometries; Customization; On-demand production	Limited material options; Low print speed; High cost
Chemical vapor deposition	Graphene[196], carbon nanotube[186], boron nitride[190], PEDOT[197], polypyrrole[198], poly(3-alkylthiophene)[199]	Deposition of thin films on substrates by the chemical reaction of gaseous precursors	High purity; Uniform coating; Low waste; Good reproducibility; Improved tensile strength and durability of fibres	High cost; Difficult for large-scale production; Time-consuming; Hazardous chemicals; Hihg energy input; Limited flexibility of fibres
Chemical reduction	Graphene oxide[200], Ag and Au nanoparticles or nanowires[201]	Removal of oxygen or the addition of hydrogen	High durability of fibres; Precise control over fibre's propertise; Large-scale manufacturing	Use of harsh chemicals; Energy consumption; Washing to remove residues in fibres; Difficult to control fibre's quality

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