Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Multifold Enhancement of the Output Power of Flexible Thermoelectric Generators Made from Cotton Fabrics Coated with Conducting Polymer

Yong Du[1*], Kefeng Cai[2], Shirley Z. Shen[3], Richard Donelson[3], Jiayue Xu[1], Hongxia Wang[4], Tong Lin[4*]

[1] School of Materials Science and Engineering, Shanghai Institute of Technology, 100 Haiquan Road, Shanghai 201418, PR China

[2] Key Laboratory of Advanced Civil Engineering Materials of Ministry of Education, School of Materials Science & Engineering, Tongji University, 4800 Caoan Road, Shanghai 201804, China

[3] CSIRO Manufacturing Flagship, Private Bag 10, Clayton South, VIC 3169, Australia

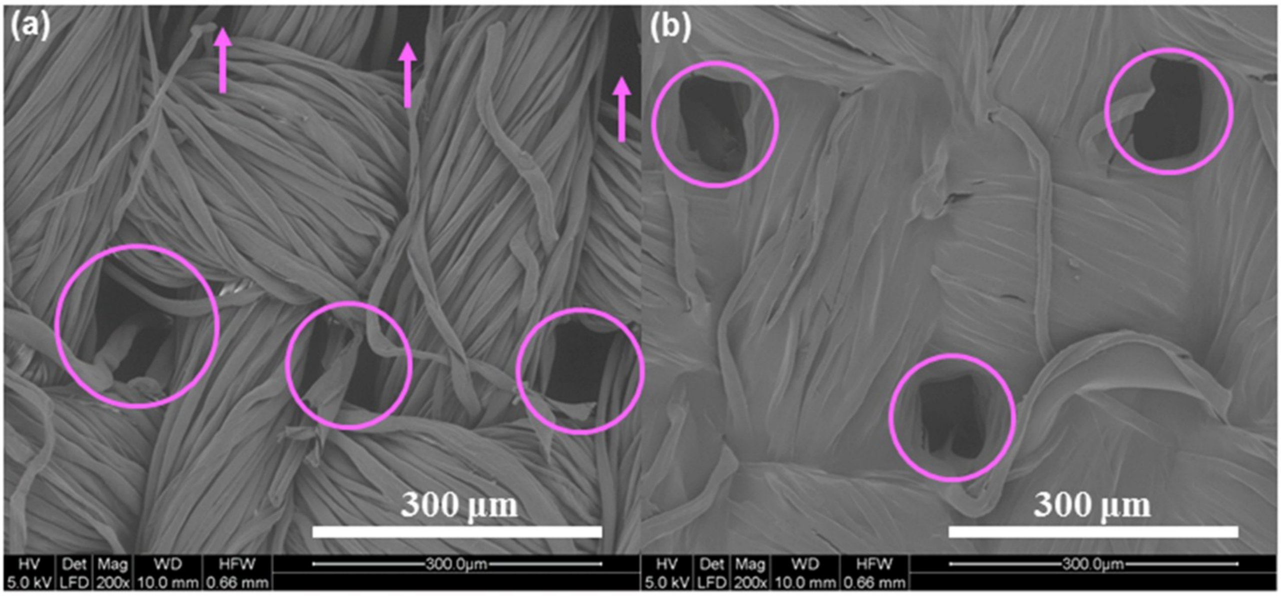
[4] Institute for Frontier Materials, Deakin University, Geelong, VIC 3216, Australia

1. Supplementary Figures

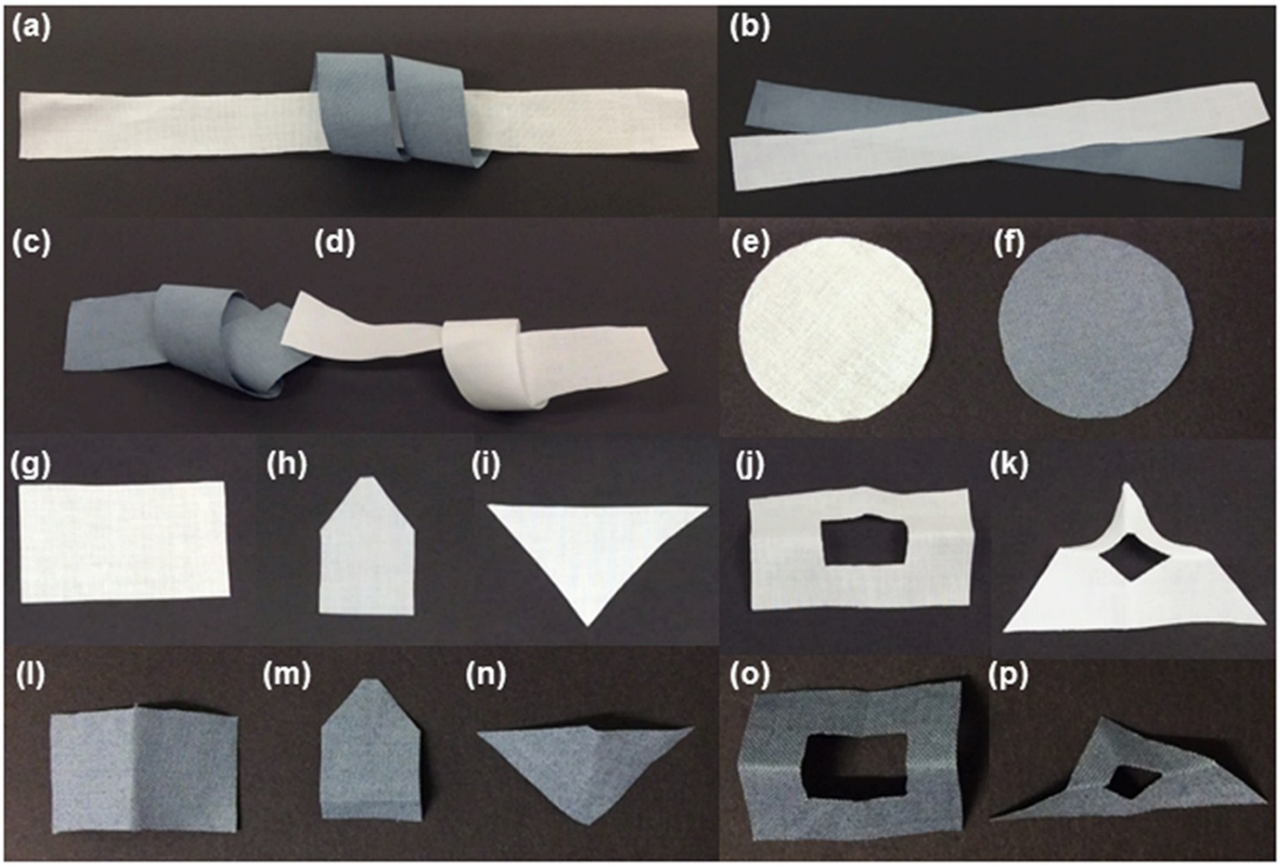
*Corresponding author:

E-mail address: ydu@sit.edu.cn

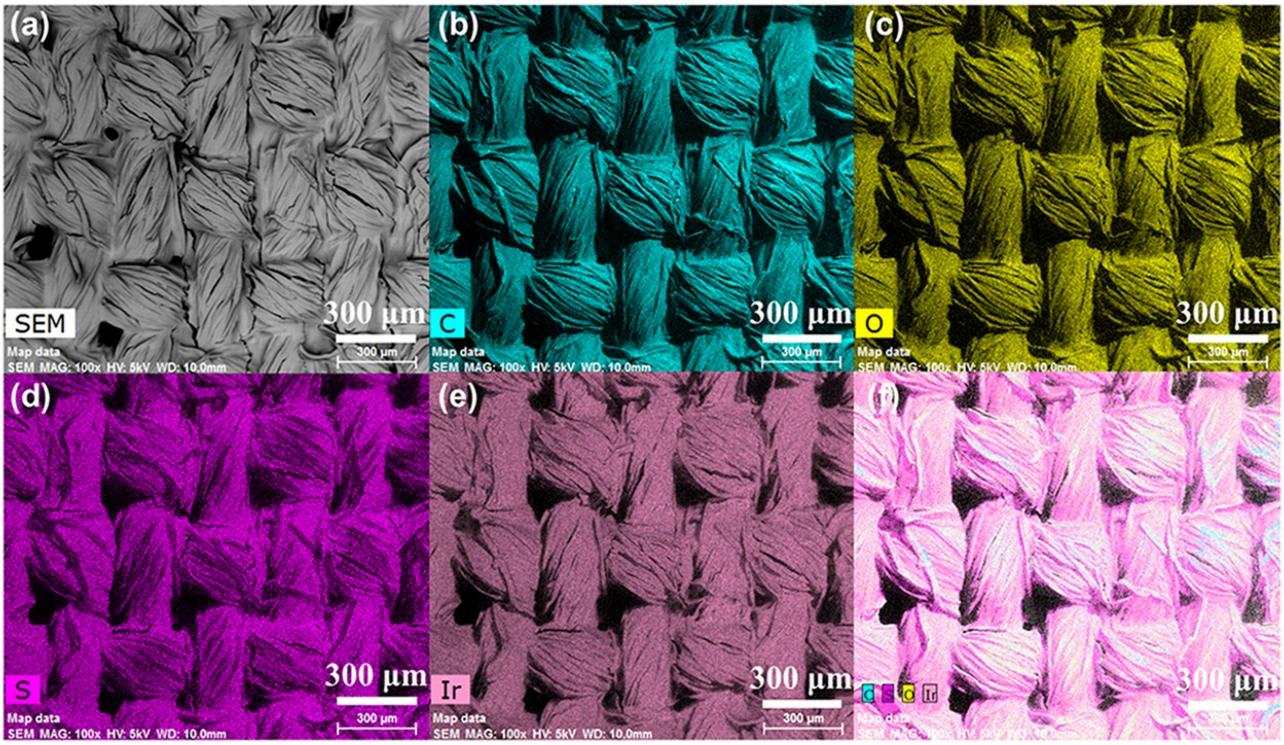
E-mail address: tong.lin@deakin.edu.au



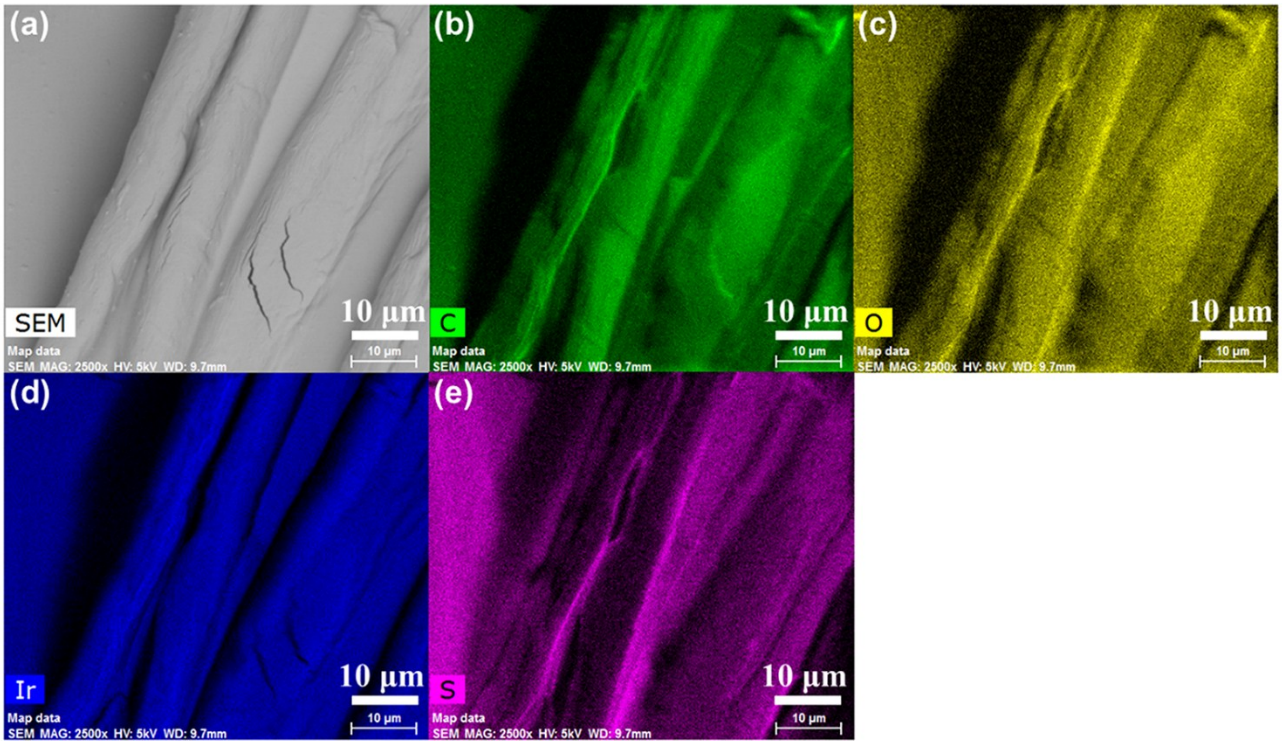
Supplementary Fig. S1 SEM images of commercial cotton fabric (a) before and (b) after PEDOT:PSS coating treatment. The holes between the warp direction and weft direction of the commercial cotton fabric was marked by pink arrows and pink circles in the Fig. S1 (a) and (b).



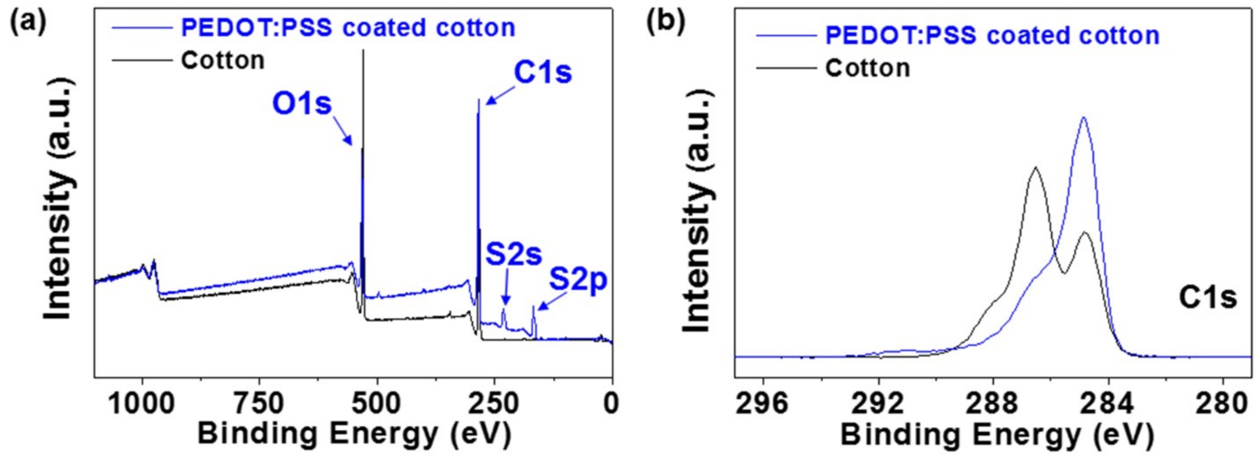
Supplementary Fig. S2 Photos of commercial cotton fabric before (the fabrics have white color) and after PEDOT:PSS coating treatment (the others fabrics).



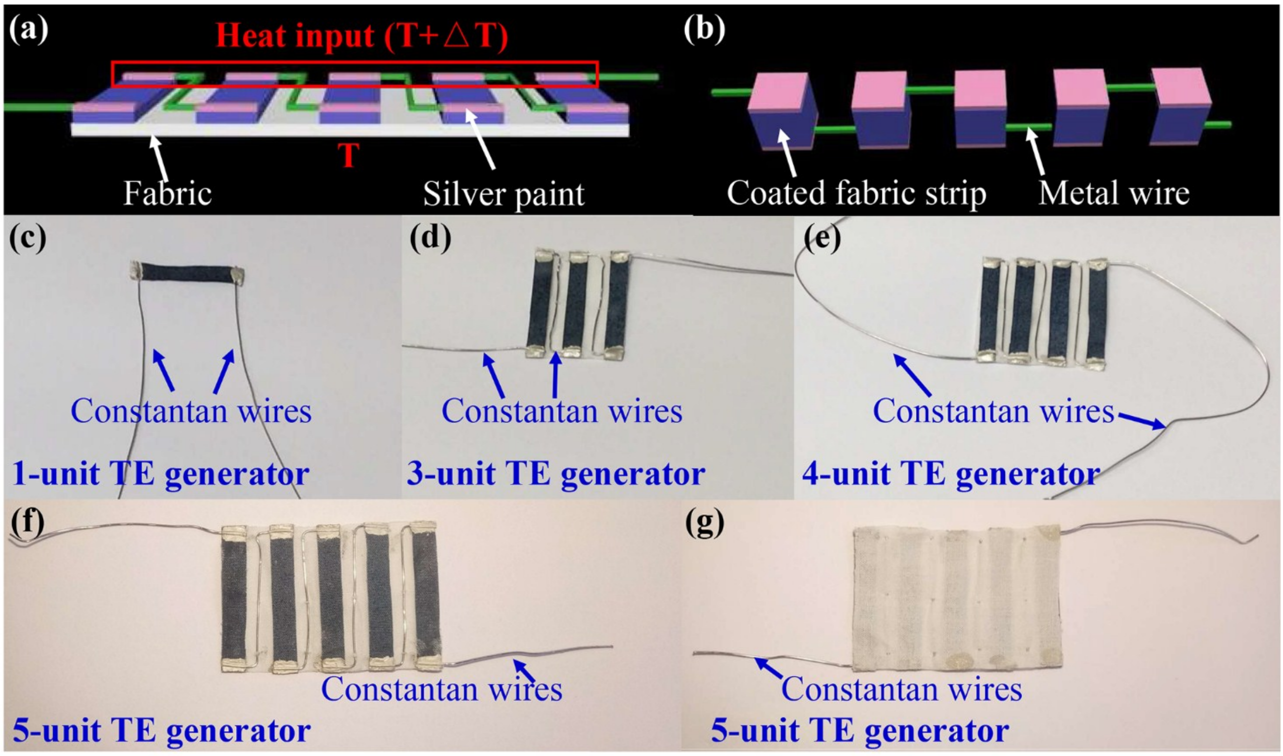
Supplementary Fig. S3 (a) SEM image and (b) - (f) SEM-EDS mapping images of the PEDOT:PSS coated cotton fabric.



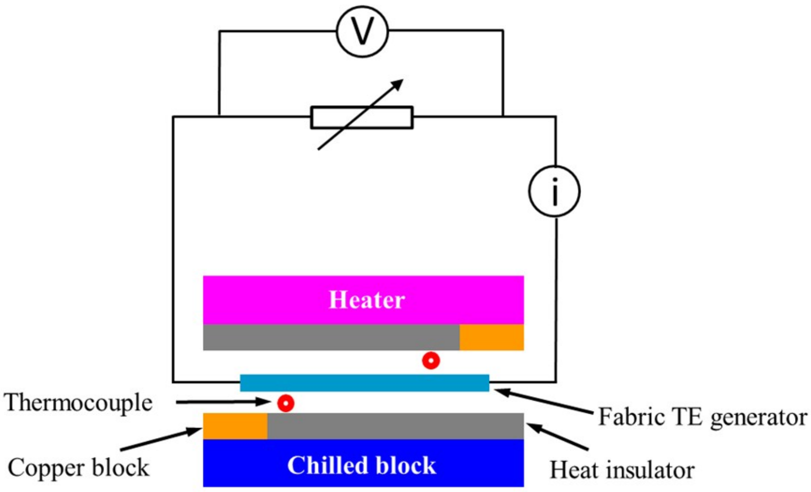
Supplementary Fig. S4 (a) SEM image and (b) - (e) SEM-EDS mapping images of the PEDOT:PSS coated cotton fibers.



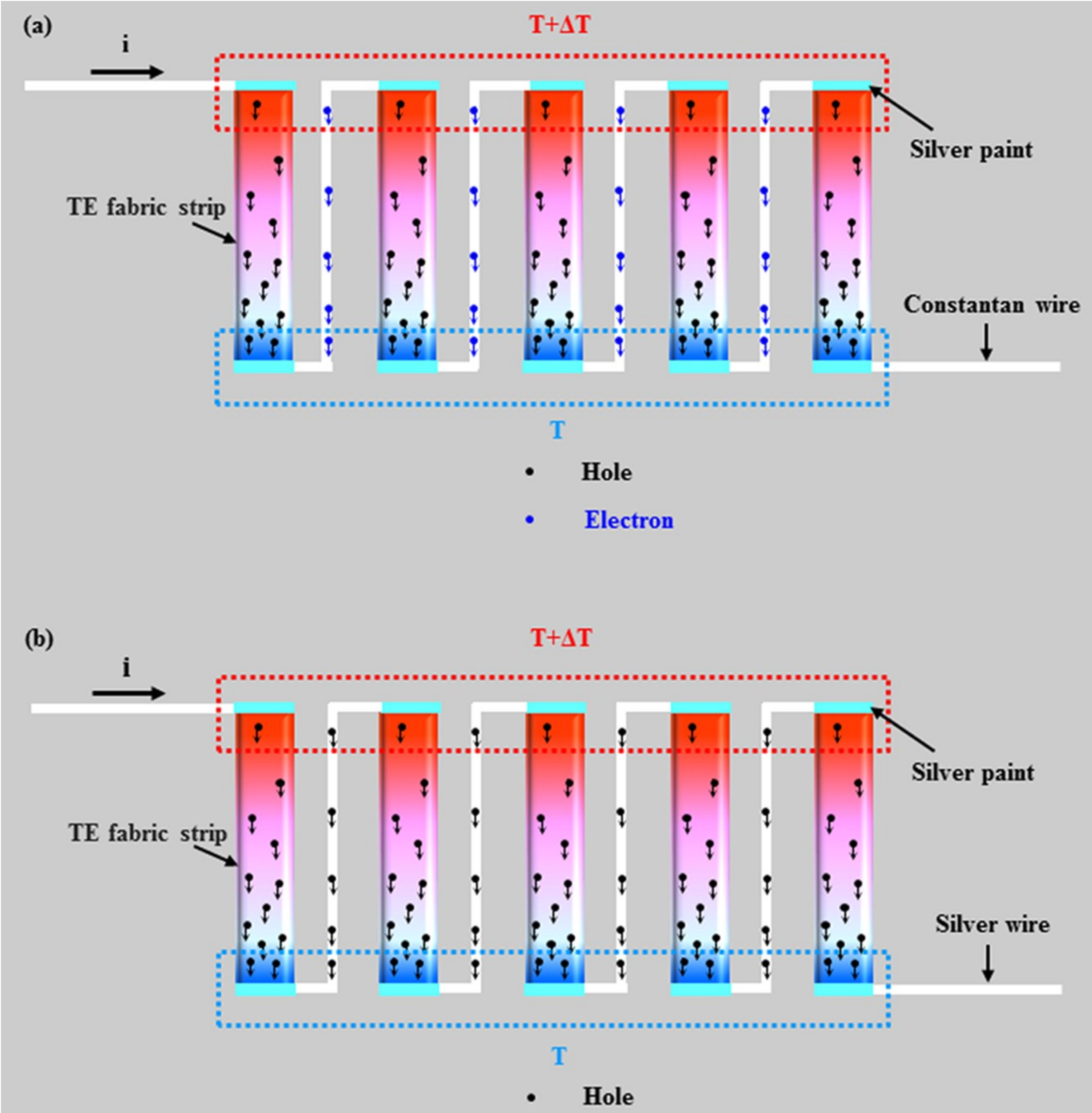
Supplementary Fig. S5 (a) XPS survey spectra and (b) high resolution C1s spectra of cotton fabric before and after PEDOT:PSS coating treatment.



Supplementary Fig. S6 Schematic illustration of the fabric-based TE generators, (a) I-type connection, and (b) π-type connection. Positive face of the fabric-based TE generators connected with Constantan wires, (c) 1-unit, (d) 3-unit, (e) 4-unit, and (f) 5-unit. Negative face of the fabric-based TE generators connected with Constantan wires, (g) 5-unit.



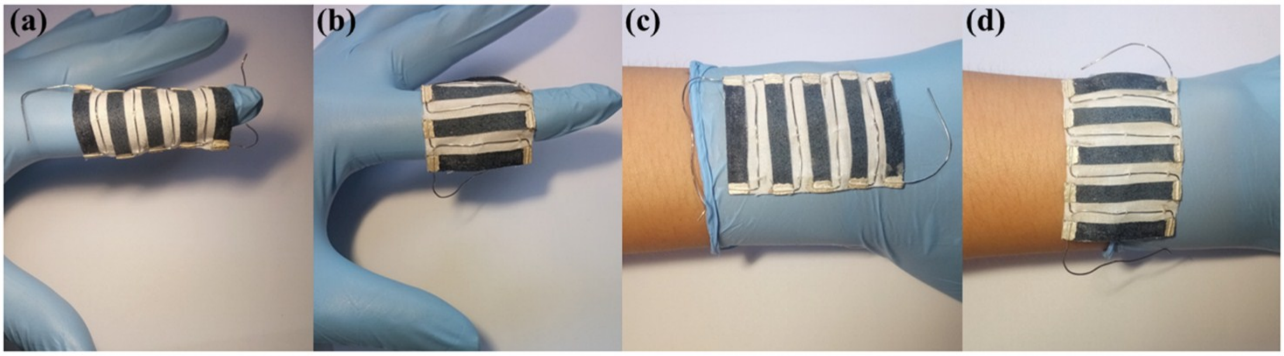
Supplementary Fig. S7 Schematic illustration of the measurement setup for evaluate the performance of the fabricated fabric-based TE generator



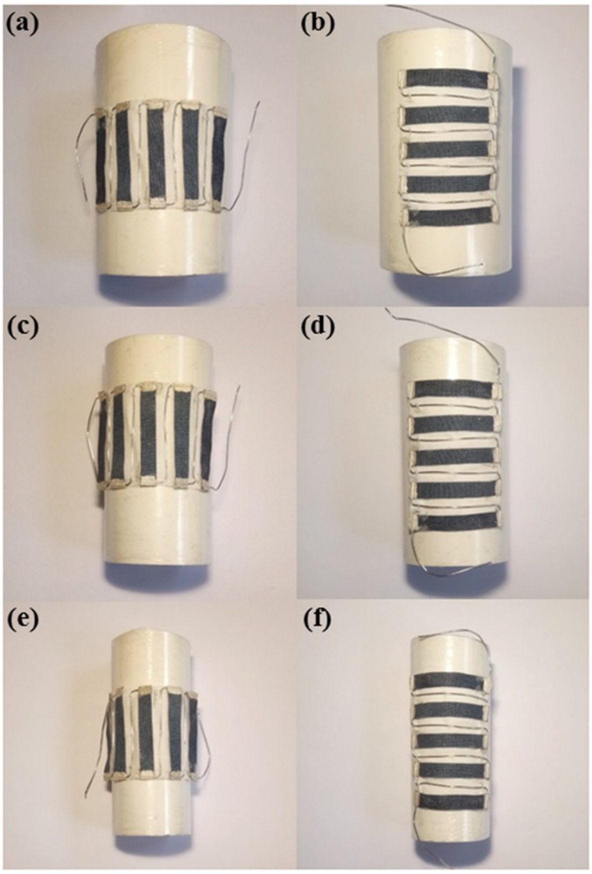
Supplementary Fig. S8 Schematic illustrations of micromechanism of fabric TE generator connected with (a) Constantan wires and (b) silver wires.

For the fabric TE generator connected with Constantan wires, when one side of the device was heated, both of the holes in the *p*-type coated fabrics and electrons in the Constantan wires moved from the hot side to the cooled side (Supplementary Fig. S8 a). As a result, the current was in the direction along the hole moving in the fabric strips, which is opposite to the electron moving in the Constantan wires. This explains why the Constantan wires have a positive effect on the V of the fabric TE generator.

For the fabric TE generator connected with silver wires, when one side of the device was heated, both of the holes in the *p*-type coated fabrics and silver wires moved from the hot side to the cooled side (Supplementary Fig. S8 b). Due to the Seebeck Coefficient of the coated cotton strip was much higher than that of the silver wire, as a result, the current was in the direction along the hole moving in the fabric strips, which is opposite to the hole moving in the silver wires. That means the silver wires have a negative effect for the *V* of the fabric TE generator prepared by using *p*-type fabric strips.

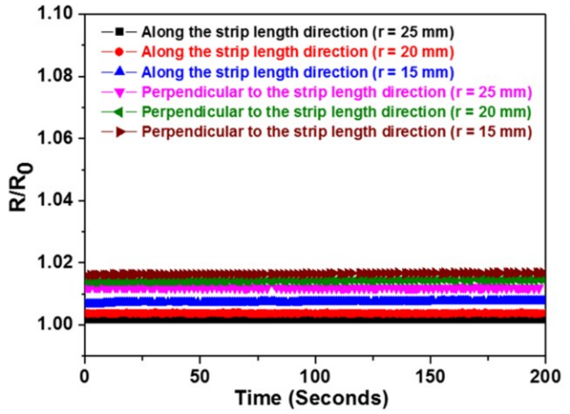


Supplementary Fig. S9 Photos of fabric-based TE generators connected with Constantan wires on the fingers (a) & (b), and (c) & (d) wrists.



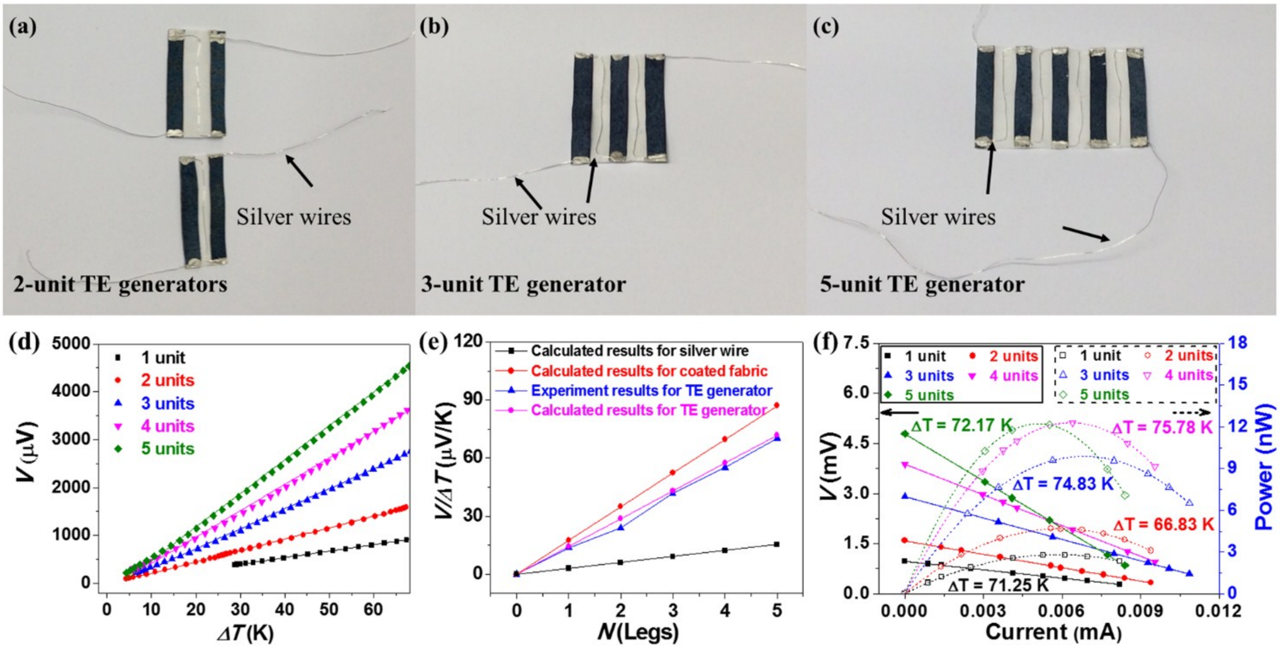
Supplementary Fig. S10 Photos of the prepared device attached on the surface of the cylinders with different radius (a) & (b) 25 mm, (c) & (d) 20 mm, and (e) & (f) 15 mm.

The fabric-based TE generator can be bent at different bending radii (e.g. 25 mm, 20 mm, and 15 mm) and in different directions (e.g. along the coating strip length direction and perpendicular to the coating strip length direction).



Supplementary Fig. S11 Effects of bending at different radii and directions on the internal resistance of the fabric-based TE power generator.

The fabric-based generators can be rolled up and bent, and they still work after being bent at different bending radii and in different directions. There is no significant change (less than 2 %) in the internal electrical resistance when bending along the coating strip length direction and perpendicular to the coating strip length direction with the bending radius of from 25 mm down to 15 mm (even kept bending for 200 seconds at each bending radius and in different directions, respectively).



Supplementary Fig. S12 Positive face of the fabric-based TE generators connected with silver wires, (a) 2-unit, (b) 3-unit, and (c) 5-unit. (d) TE voltage generated versus ΔT, (e) the experimental results and calculated results based on equation (1), for the TE voltage generated per 1 K ΔT ($V/\Delta T$) versus N, and (f) the output voltage and power as a function of current (by adjusting the load resistance with different values) for the prepared 5-strip fabric-based devices connected by silver wires.

As the N increasing, the $V/\Delta T$ of both fabric TE generators increased in a linear relationship. A 5-strip fabric TE generator connected with silver wires had a $V/\Delta T$ of 70.28 μV/K (Supplementary Fig. S12 d & e), which is corresponding to the value calculated based on the equation (1), 71.8 μV/K (V = (17.43-3.07) × 5. It should be noted that 3.07 μV/K is the Seebeck coefficient at ~ 300 K for the silver wire [1]). The experimental $V/\Delta T$ results for a 5-strip fabric TE generator connected with silver wires is slight lower than that of the calculated value (87.15 μV/K, 17.43 μV/K × 5), and it is much higher than that of the calculated value for 5 strip silver wire 15.35 (3.07 μV/K × 5) (Supplementary Fig. S12 e). This result also confirm that *p*-type silver wire has a negative effect for the V of the fabric TE generator due to the coated fabric strip was also *p*-type.

2. Supplementary Table

Supplementary Table 1 The output voltage and power for the typically flexible TE generators reported.

Device name and methods	***p*-type materials**	***n*-type materials or metal wires or metal foil**	**Number of TE legs**	***V***	**P_{max}**	**Ref.**
Polymer-based fabric generator (dispenser printing)	$Bi_{0.5}Sb_{1.5}Te_3$ and adhesive binder solution	$Bi_2Se_{0.3}Te_{2.7}$ and adhesive binder solution	12 couples	～ 25 mV, ΔT = 20 K	224 nW, ΔT = 20 K	[2]
Glass fabric-based generator (screen printing)	Sb_2Te_3, liquid adhesive binder, and deionized water	Bi_2Te_3, liquid adhesive binder, and deionized water	8 couples	90 mV, ΔT = 50 K		[3]
Silk fabric-based generator (repeatedly depositing)	Sb_2Te_3	Bi_2Te_3	12 couples	～10 mV, ΔT = 35K	～15 nW, ΔT = 35K	[4]
Carbon nanotube (CNT)/polymer composite based fabric generator (layer arrangement)	CNT (*p*-type)/ polyvinylidene fluoride	CNT (*n*-type)/ polyvinylidene fluoride	72 layers	26 mV, ΔT = 50K	137 nW, ΔT = 50K	[5]
Nonwoven fabric module impregnated with PEDOT:PSS	PEDOT:PSS/ fabric composites,	Ni foil	Six fabric pieces	～ 6 mV, ΔT = 48.5 K		[6]
PEDOT:PSS coated polyester fabric-based generator (solution coating)	PEDOT:PSS coated polyester fabric strips	Silver wires	5 strips	4.3 mV, ΔT = 75.2 K	12.29 nW, ΔT = 75.2 K	[1]
PEDOT:PSS coated cotton fabric-based generator (solution coating)	PEDOT:PSS coated cotton fabric strips	Silver wires	5 strips	4.8 mV, ΔT = 70.9 K	12.16 nW, ΔT = 72.2 K	This work
PEDOT:PSS coated cotton fabric-based generator (solution coating)	PEDOT:PSS coated cotton fabric strips	Constantan wires	5 strips	18.7 mV, ΔT = 74.3 K	212.6 nW, ΔT = 74.3 K	This work

References

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