High-conductivity Graphene/Carbon Black Inks by Interpenetrating Networks for Wearable Fabric-based Heaters and Strain Sensors

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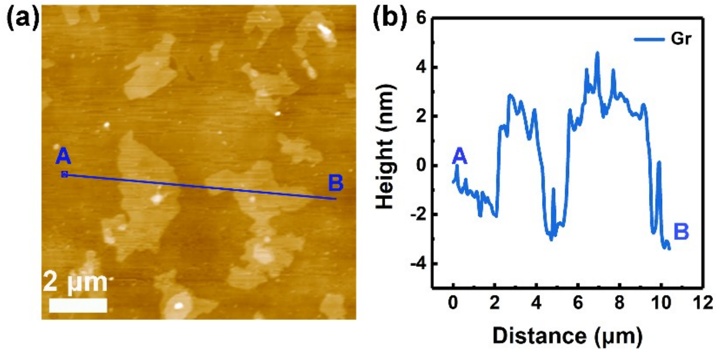

Fig. S1 (a) AFM image and (b) height profiles of Gr on a mica sheet.

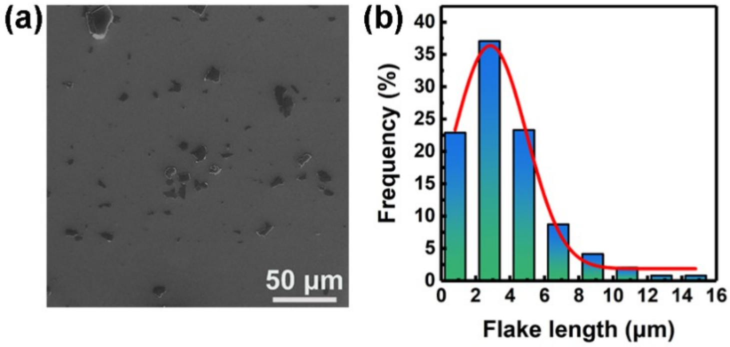

Fig. S2 (a) SEM image of Exfoliated Gr/CB dispersion, (b) histograms of lateral flake size.

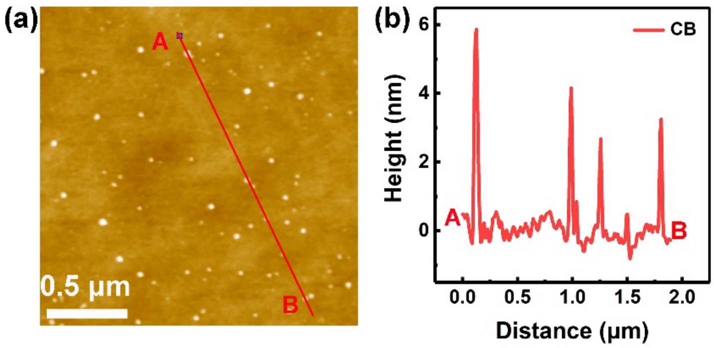

Fig. S3 (a) AFM image and (b) height profiles of CB on a mica sheet.

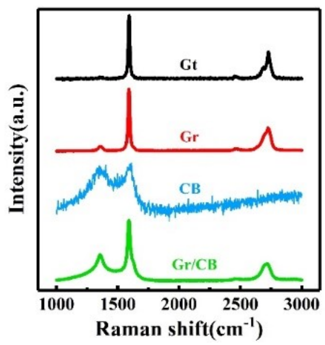

Fig. S4 Raman spectra for Gt, Gr, CB, and Gr/CB dispersion.

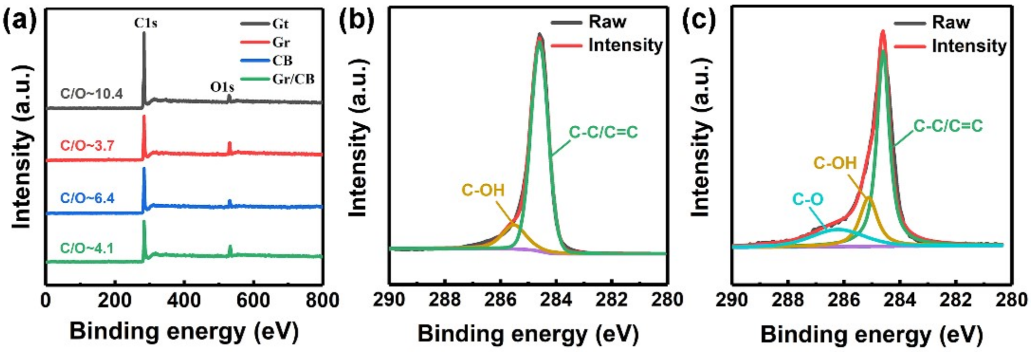

Fig. S5 (a) XPS survey spectra of Gt, Gr, CB, and Gr/CB. High-resolution C_{1s} of (b) the Gt and (c) the exfoliated Gr/CB dispersion.

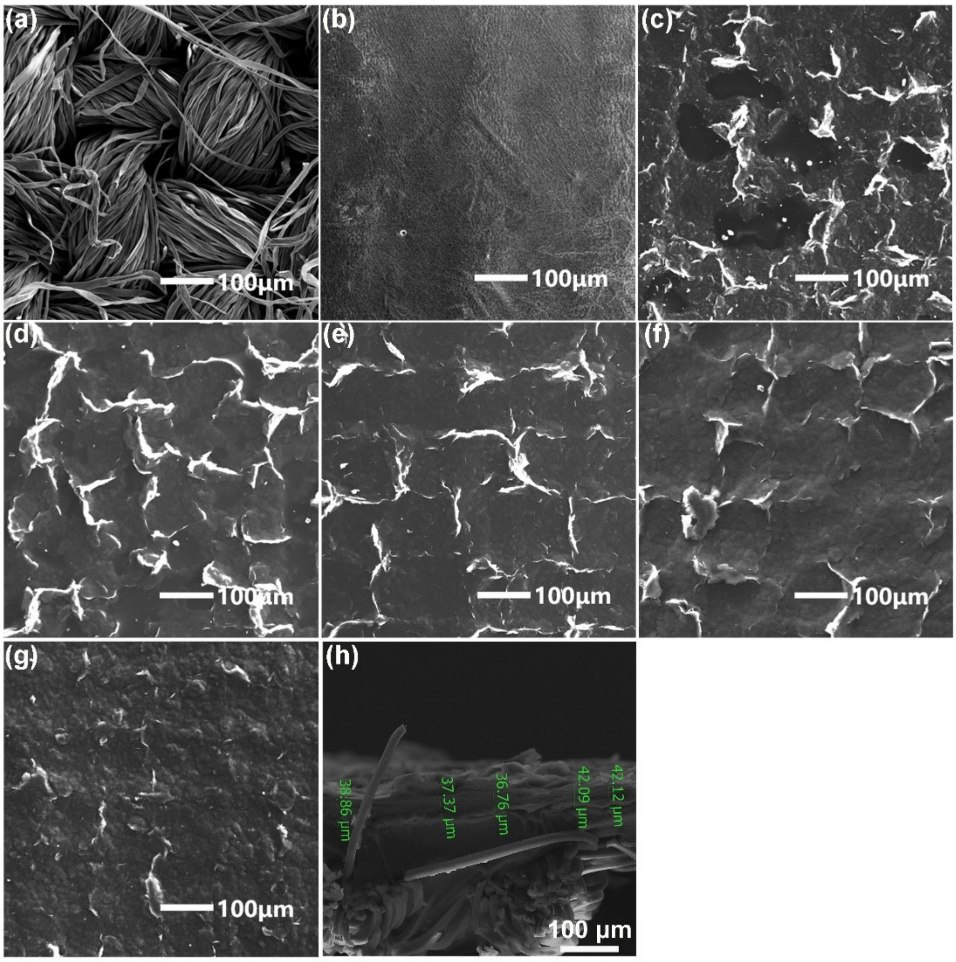

Fig. S6 SEM images of (a) pristine fabric, (b) TPU-Fabric. SEM image of the number of different screen-printing cycles of Gr/CB@TPU-Fabric(c) 1 cycle, (d) 2 cycles, (e) 3 cycles, (f) 4 cycles, (g) 5 cycles. (h) SEM cross-section images of Gr-ink@ Fabric for printing 4 cycles.

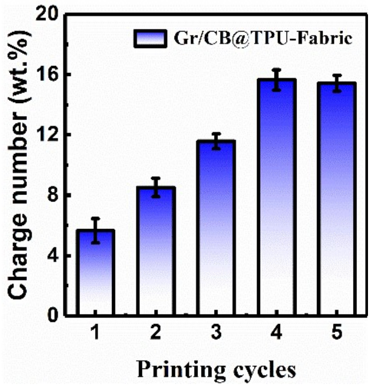

Fig. S7 Relationship between the number of screen-printing cycles and charge number of Gr/CB@TPU-Fabric.

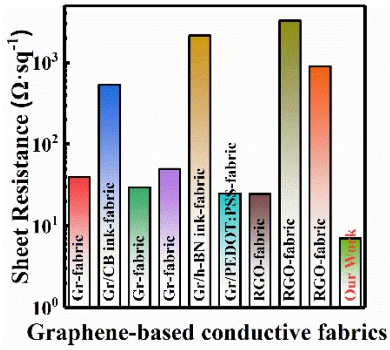

Fig. S8 Comparison of the electrical properties of the Gr/CB@TPU-Fabric and previously reported graphene-based conductive fabrics.

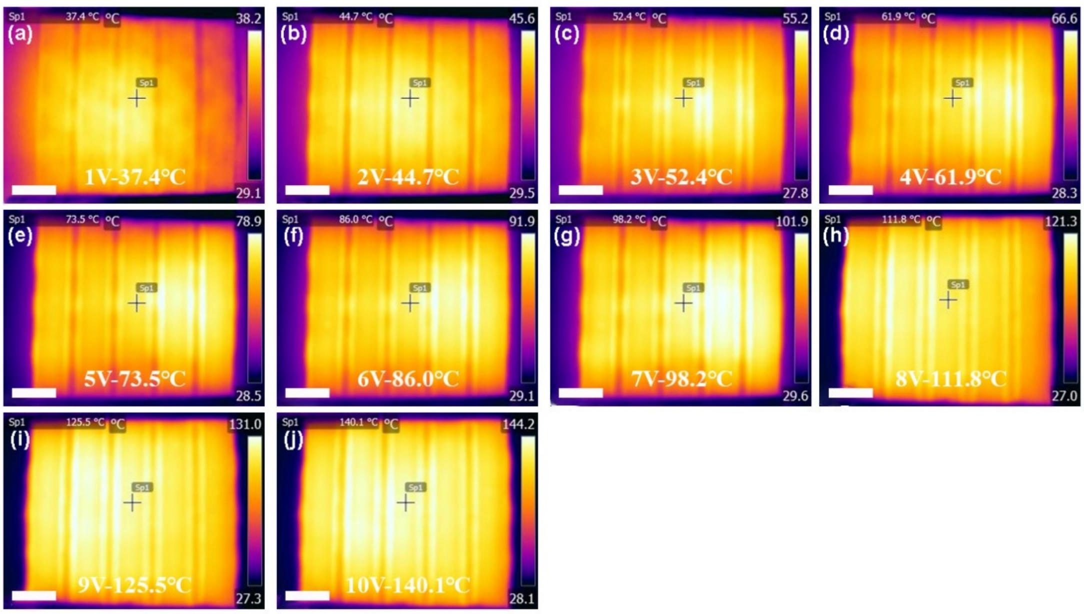

Fig. S9 The IR thermal photographs of the Gr/CB@TPU-Fabric (Scale bar: 2 cm).

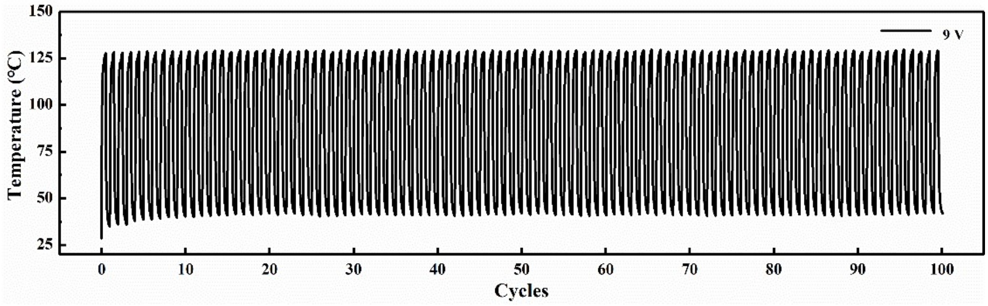

Fig. S10 Heating-cooling cycles stability of graphene conductive fabric under 9 V.

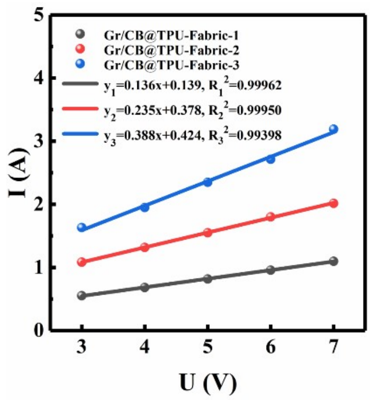

Fig. S11 The relationship between various parameters of Gr/CB@TPU-Fabric with different areas for Voltage and current.

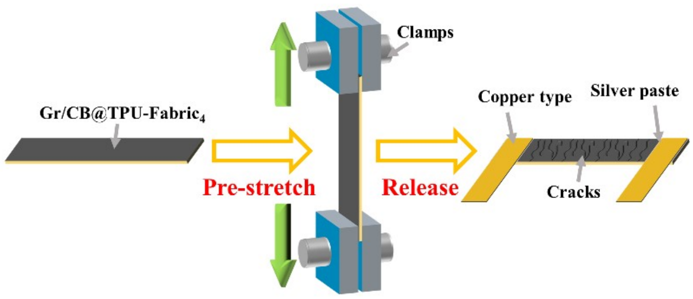

Fig. S12 Schematic diagram of preparation process of Gr/CB@TPU-Fabric-based strain sensor.

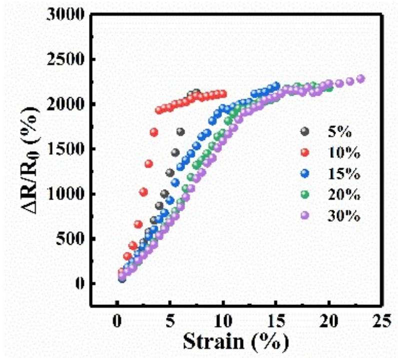

Fig. S13 The relationship between the relative resistance changes and Gr/CB@TPU-Fabric-based strain sensor strain with different pre-stretching strains.

Table S1. Summary of some wearable fabric-based heaters and their performances.

Heating Materials	Heating Area (cm^2)	Voltage Range (V)	Temperature at low voltage (°C)	Ref.
Ag NPs/MXene	<5×5	10-17.5	37.7 (10 V)	[32]
rGO/CNT/Cu	2×2	2-5	51.0 (4 V)	[33]
Gr/CNT/PEDOT:PSS	3×2	10-30	42.3 (10 V)	[34]
MXene/Ppy	3×3	4-10	40.1 (4 V)	[35]
PEDOT	4×4	2-10	24.1 (2 V)	[36]
PEDOT:PSS	1×1	3-6	27.0 (3 V)	[37]
PEDOT:PSS/rGO	3×1	5-30	31.5 (5 V)	[38]
rGO/Ppy	2×2	3-9	42.4 (3 V)	[39]
Gr/CB ink	8.5×16	3-7	53.4 (3 V)	Our work

Table S2. Summary of performance of flexible fabric-based strain sensors.

Materials	Methods	Strain range (%)	GF	Response Time (ms)	Ref.
Graphene	CVD	＜10	34.3-48.9 (8%)	-	40
RGO	Dipping	0.05-75	~8.9 (＜5%)	-	41
Gr/PVDF/PU	Phase-separation	0.01-10	51 (0-5%) 87 (5-8%)	＜100	42
RGO	Wet-spinning/ Vacuum filtration	0.24-70	1200 (20%)	~30	43
RGO/TPU	Electrospinning	0-150	~50 (50%)	＜160	44
GNPs/CB	Dip-coating	0-60	5.62 (4%)	＜209	45
GNPs/CB ink	Dip-coating	0-200	5 (0-127%) 7.75 (127-200%)	~172	46
RGO	Dip-coating	0-100	10 (＜1%) 3.7 (＜50%)	＜100	47
GNPs	LbL	0-150	1.4	-	48
GO	Screen-printing	-	-	-	49
Graphene	Coating	0-80	6.04 (0-21%) 1.97 (26-80%)	-	50
RGO ink	Spraying	0-23	60 (＜10%) 1747 (~15-20%)	80	51
MXene/ PANI	Dip-coating	0.5-100	~16.66	90	52
PANI/RGO	Dipping	0-50	24 (0-5%) 6 (5-20%) 1.27 (20-50%)	85	53
RGO	Dip and reduce	0-150	1.5 (0-10%) 6 (10-150%)	40	54
Gr/CB ink	Screen-printing	0-10	307.79 (0-1.8%) 628.61 (1.8-4%) 30.83 (4-10%)	87.4	This work