Supplementary Information

Hybrid 1D/2D nanocarbon-based conducting polymer nanocomposites for high-performance wearable electrodes

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Table S1. Parameters of the fabricated conducting nanocomposite film.

Materials		Ratio of materials in PDMS (SWCNTs / r-GO)	Curing conditions	
			Temp. (℃)	Time (h)
Fabricated nanocomposite conducting film	PDMS-r-GO	0 : 2	130	2

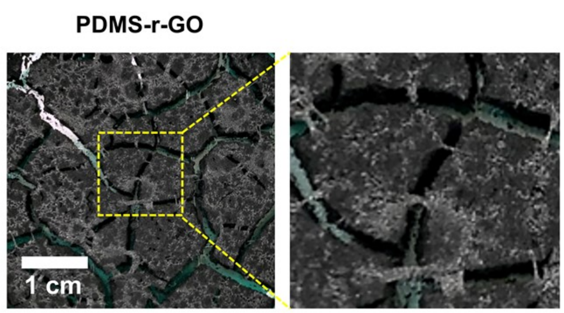


Fig. S1 Digital photographs of the PDMS-r-GO sample. The nanocomposite film based on PDMS-r-GO (2 wt.%) shows a small broken structure despite the equal fabrication process.

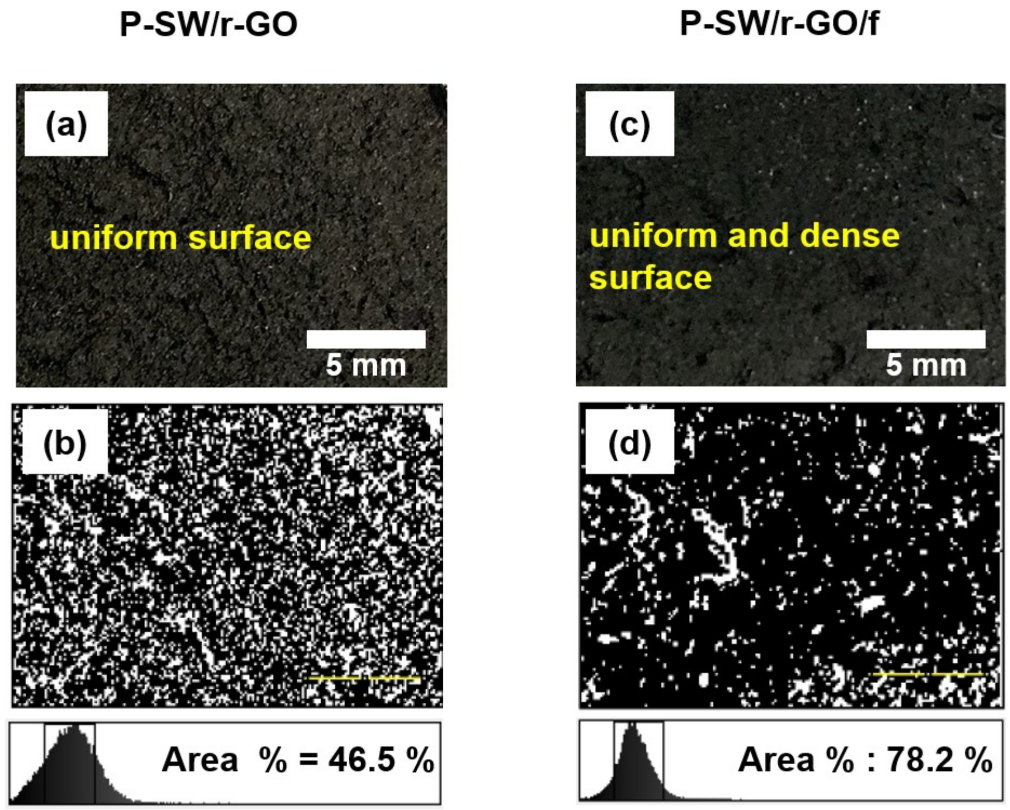


Fig. S2 Area fraction measurement of darkness on surface of P-SW/r-GO and P-SW/r-GO/f samples using ImageJ analysis. (a) digital photograph and (b) ImageJ of the P-SW/r-GO. (c) digital photograph and (d) ImageJ of the P-SW/r-GO/f. Area fraction values of P-SW/r-GO and P-SW/r-GO/f are indicated 46.5 and 78.2 %, respectively.

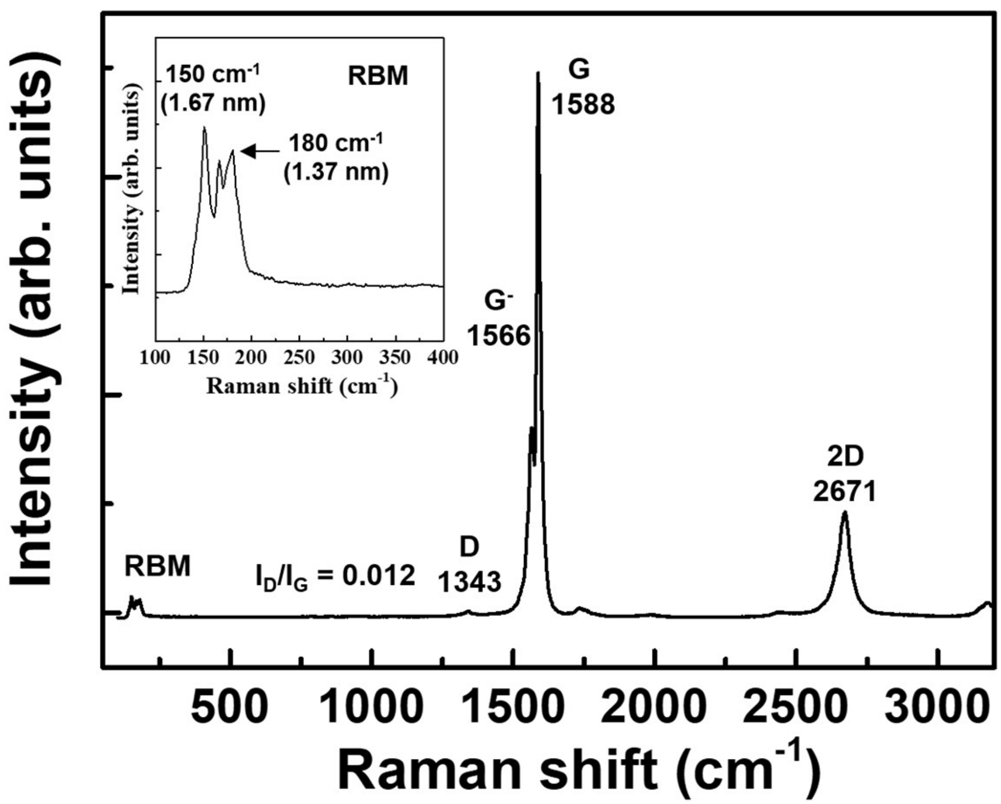


Fig. S3 Raman spectra of the pristine SWCNTs. The inset shows RBM region of the SWCNTs.

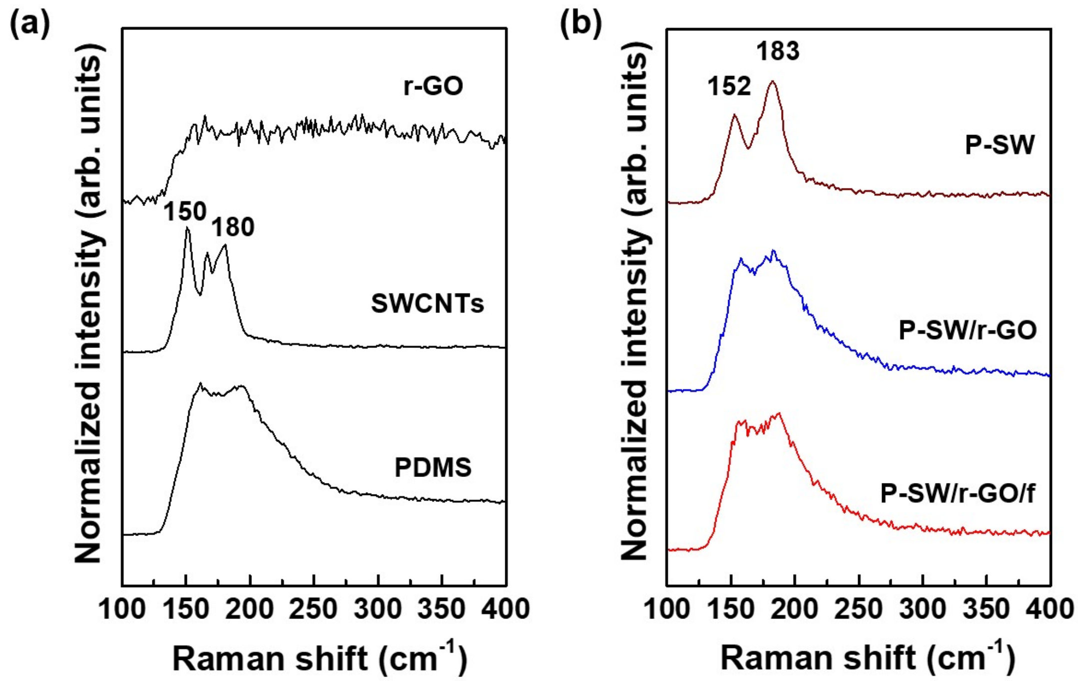


Fig. S4 Raman spectra in RBM region. (a) PDMS, SWCNTs, and r-GO as raw samples. (b) P-SW, P-SW/r-GO and P-SW/r-GO/f as conducting nanocomposite films.

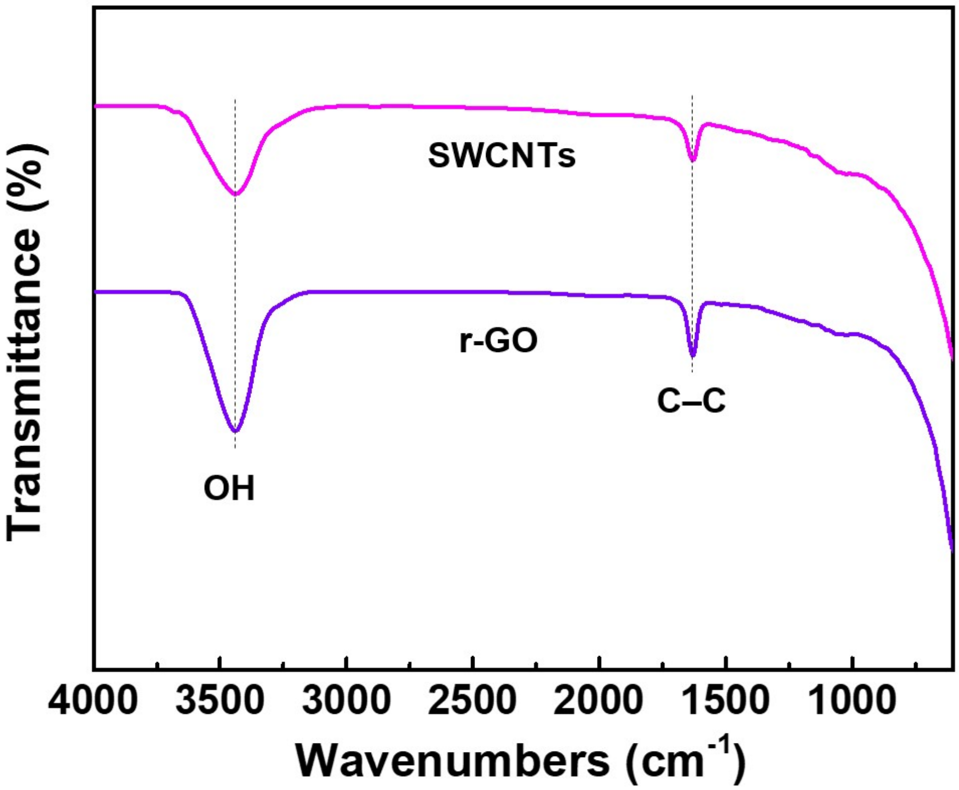


Fig. S5 FTIR spectra of pristine SWCNTs and r-GO samples.

Table S2. XPS elemental analysis results for pristine and nanocomposite samples.

Materials		Element (at.%)			
		C	O	Si	Total
Pristine samples	PDMS	49.3	24.0	26.7	100
	SWCNTs	96.0	2.8	1.2	100
	r-GO	93.1	5.1	0.6	100
Fabricated nanocomposite conducting films	P-SW	48.8	24.3	26.9	100
	P-SW/r-GO	51.3	22.9	25.8	100
	P-SW/r-GO/f	46.4	26.5	27.1	100

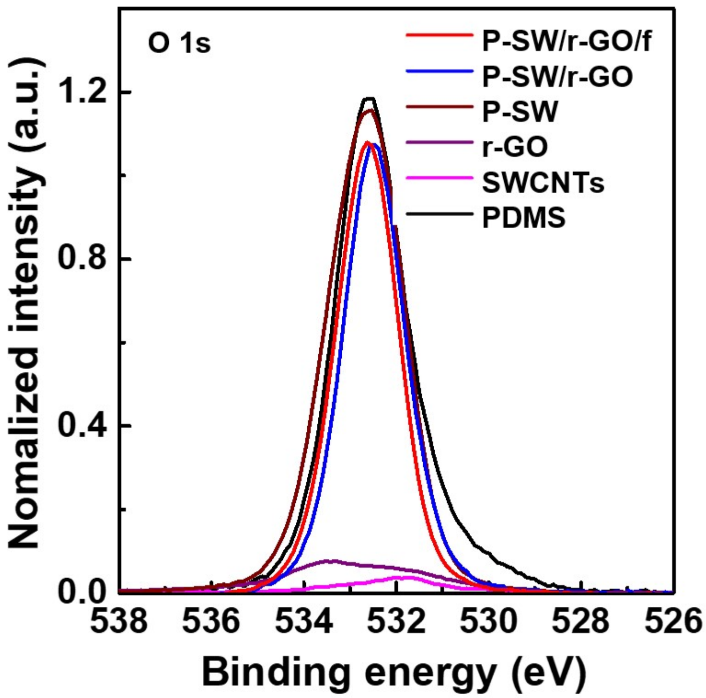


Fig. S6 O 1s XPS spectra of the PDMS, SWCNTs, r-GO, and conducting nanocomposite films.

Table S3. FWHMs of C 1s spectra for pristine and nanocomposite samples.

Samples	FWHMs form C 1s spectra (eV)
PDMS	1.722
SWCNTs	0.954
r-GO	1.181
P-SW	1.720
P-SW/r-GO	1.455
P-SW/r-GO/f	1.491

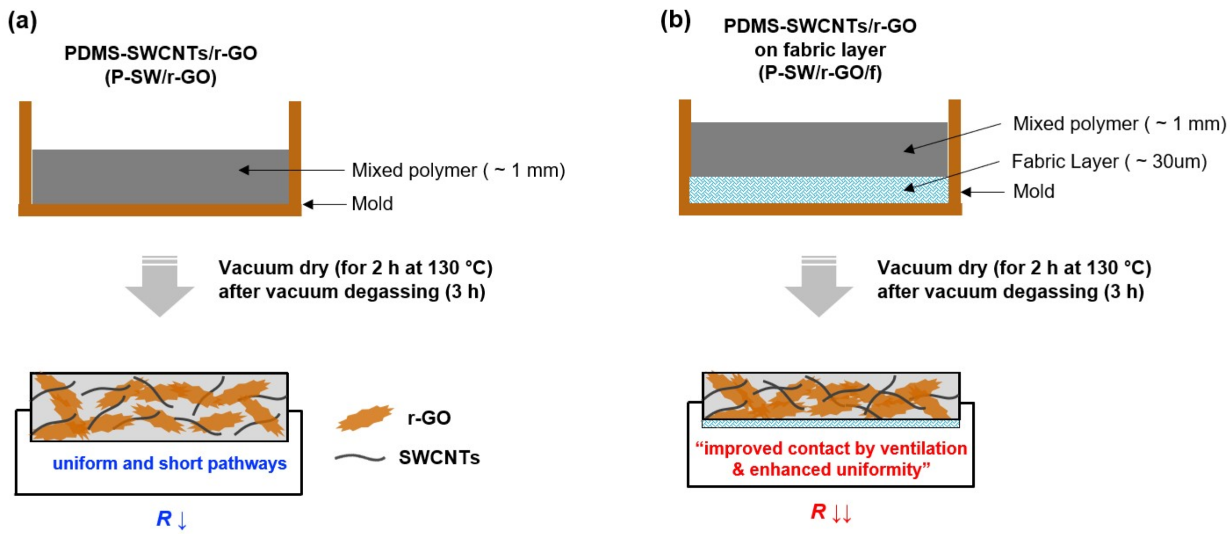


Fig. S7 Schematic of the fabricated conductive nanocomposite electrode for the (a) P-SW/r-GO and (b) P-SW/r-GO/f samples.

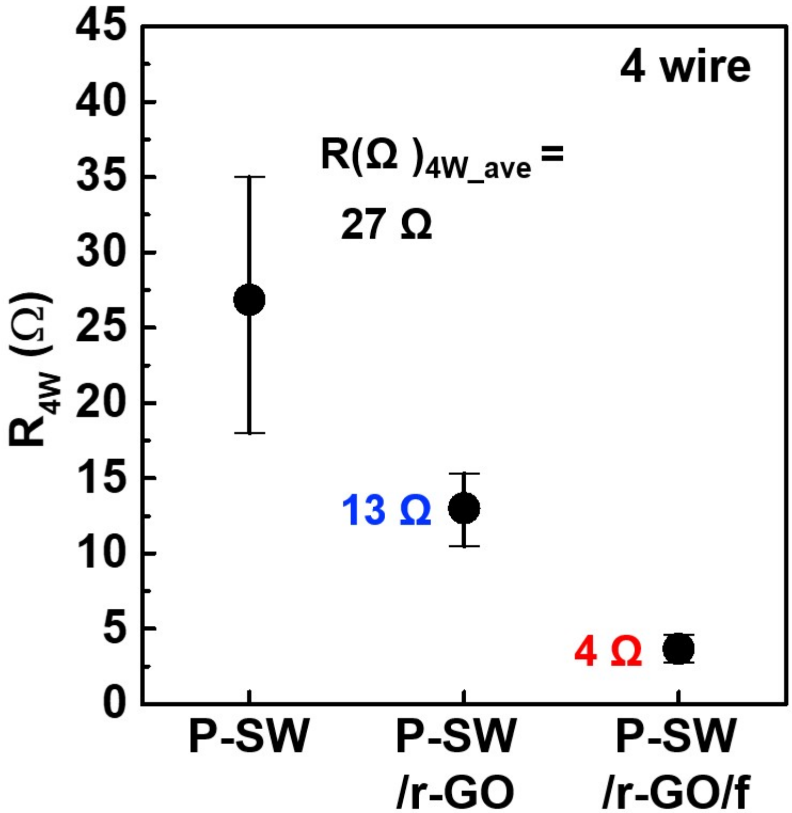


Fig. S8 Electrical resistances of P-SW, P-SW/r-GO and P-SW/r-GO/f as conducting nanocomposite films by four-probe measurement.

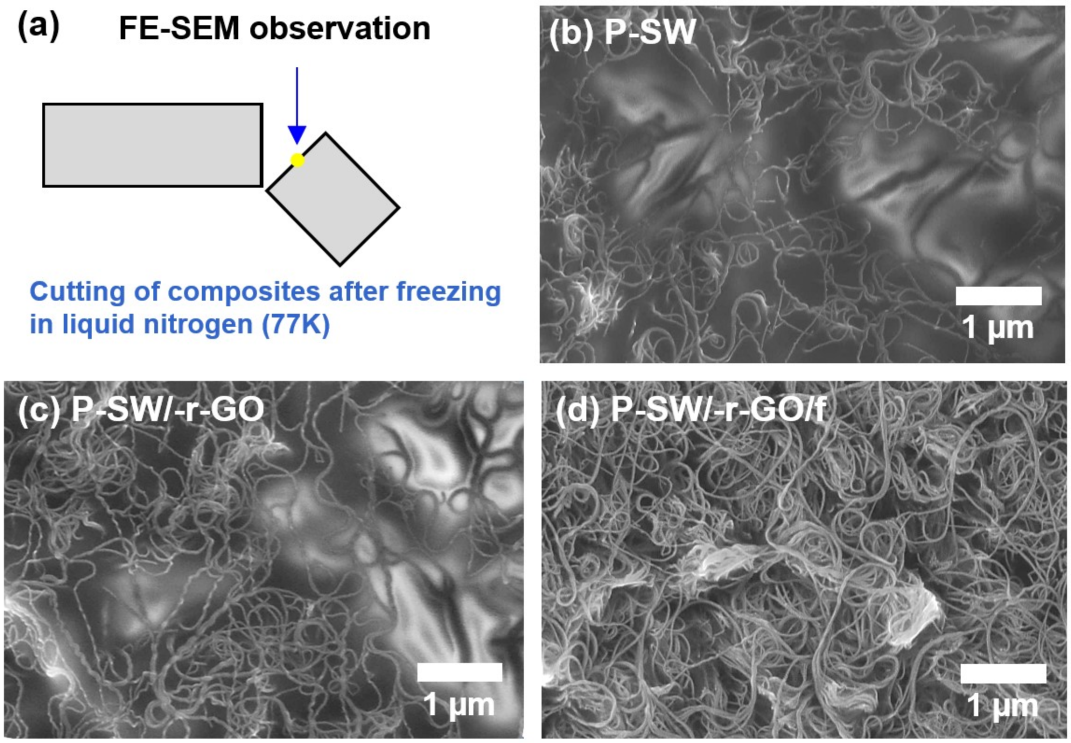


Fig. S9 Cross-sectional FE-SEM images of the fabricated conducting nanocomposite films for (a) schematic of cutting composites, (b) P-SW, (c) P-SW/r-GO, and (d) P-SW/r-GO/f. Without charging, distinct cross-sectional images of P-SW/r-GO/f were observed via FE-SEM, owing to improved conductivity.

(a) (b)

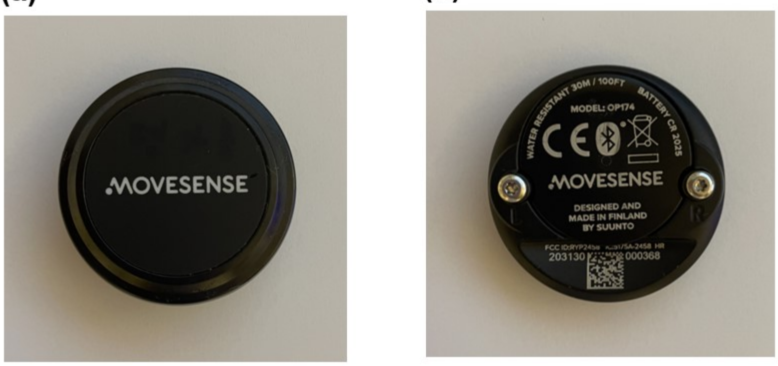


Fig. S10 Photographic images of the Movesense sensor (MODEL: OP174; diameter 36.6 mm & weight 9.4 g) (a) front and (b) back.

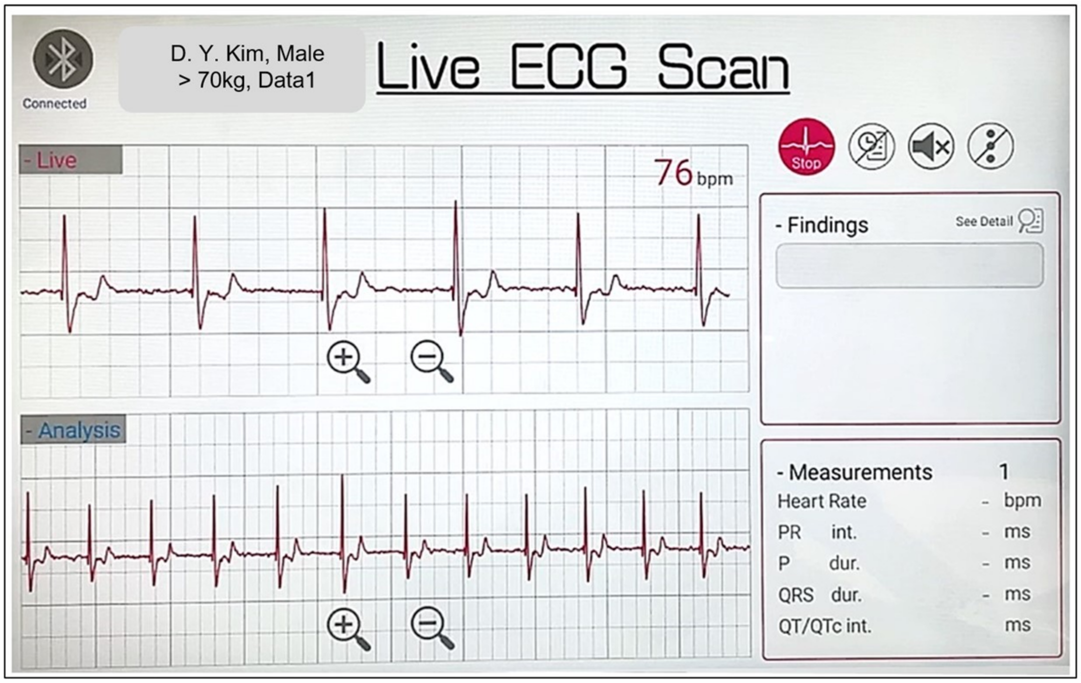
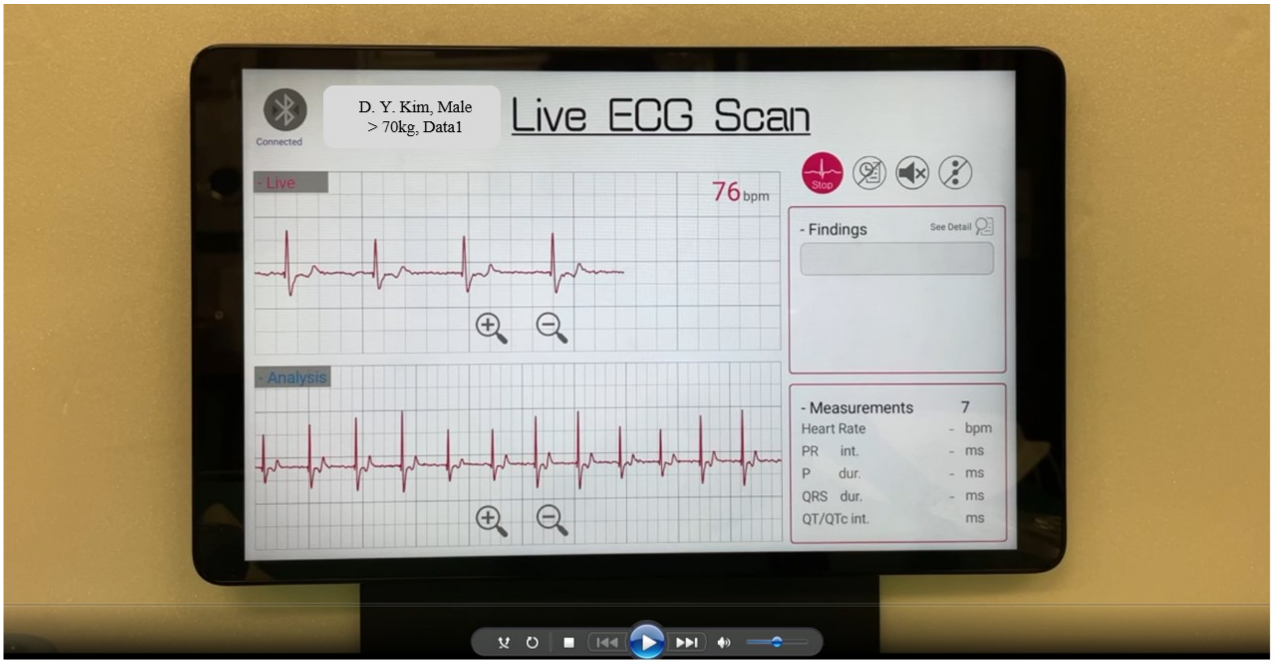


Fig. S11 Self-developed tablet application for Bluetooth ECG monitoring.



Movie S1 Real-time measured ECG signal monitoring using self-developed tablet application.

Table S4. Comparison of the electrical properties of carbon nanomaterial-based composites.

Carbon Materials	Conducting polymer	Material concentration	Electrical properties	Reference
SWCNTs	SWCNT/hydrogel structure		100–350 Ω/sq.	[1]
MWCNTs	Elastic CNT/PDMS composite	1–20 wt.%	2–7000 Ω/sq.	[2]
Graphene nanoplatelets	Screen printed graphene electrode on textile	-	104 Ω/sq.	[3]
Graphene powder	Electronic tattoos based on silk and graphene	40 wt.%	96 ± 8 Ω/sq.	[4]
Graphene flakes	Electroconductive polymer spray-coated 3D porous graphene	-	13–32 Ω/sq.	[5]
SWCNTs /r-GO	PDMS-based hybrid 1D SWCNTs/2D r-GO	SWCNTs (1 wt.%)/ r-GO (1 wt.%)	4 Ω/sq. (at 4 wire) 15 Ω (at 2 wire)	This work

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