

Supporting Information

Screen Printing of a Highly Conductive Graphene Ink for Flexible Printed Electronics

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Supplementary Figures

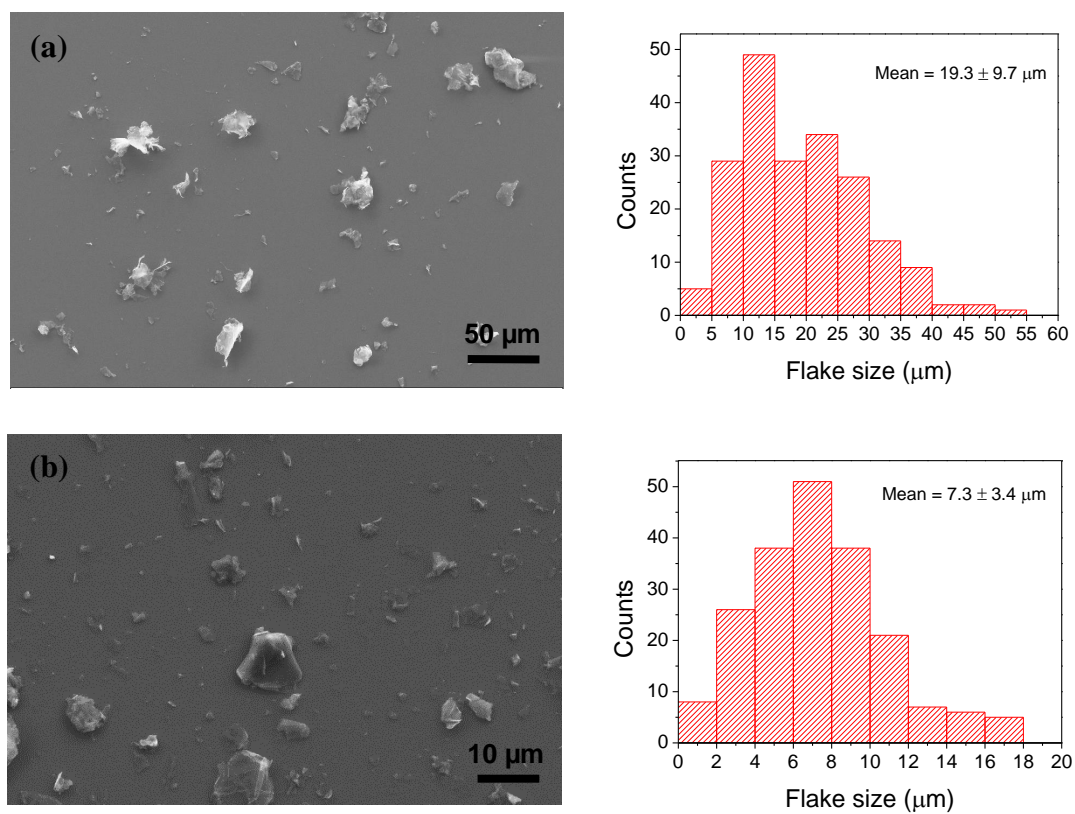


Figure S1. Representative SEM images and flake size distribution of GNP flakes before (a) and after (b) tip sonication process.

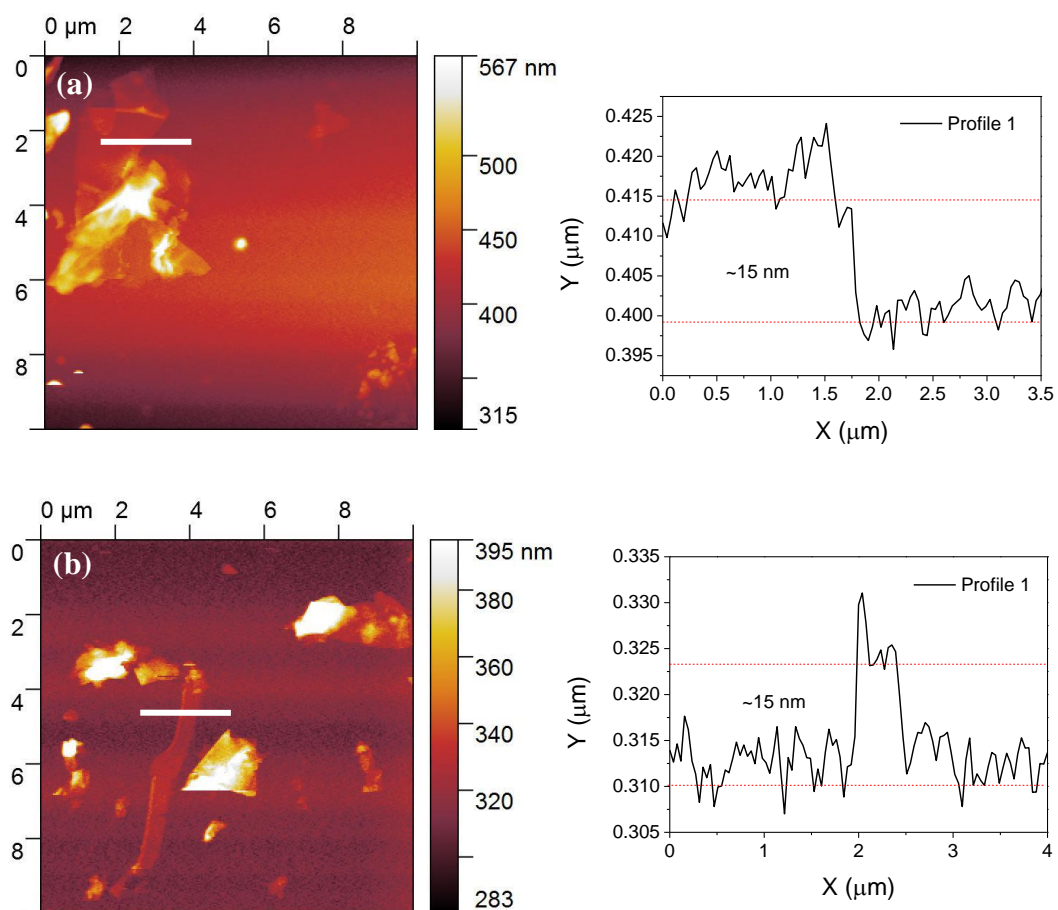


Figure S2. AFM images and corresponding height profile of GNP flakes before (a) and after (b) tip sonication process.

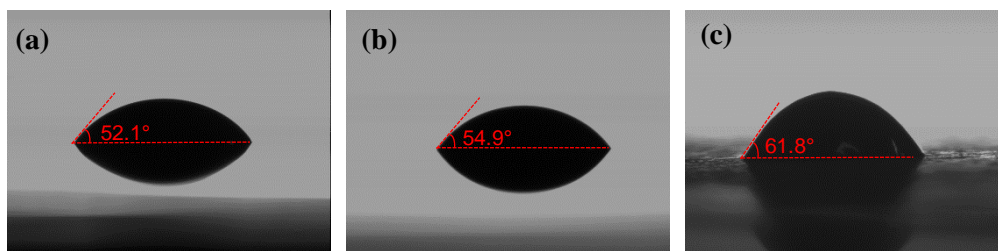


Figure S3. Images of contact angles for graphene ink on different substrates: (a) PI, (b) PET, and (c) paper.

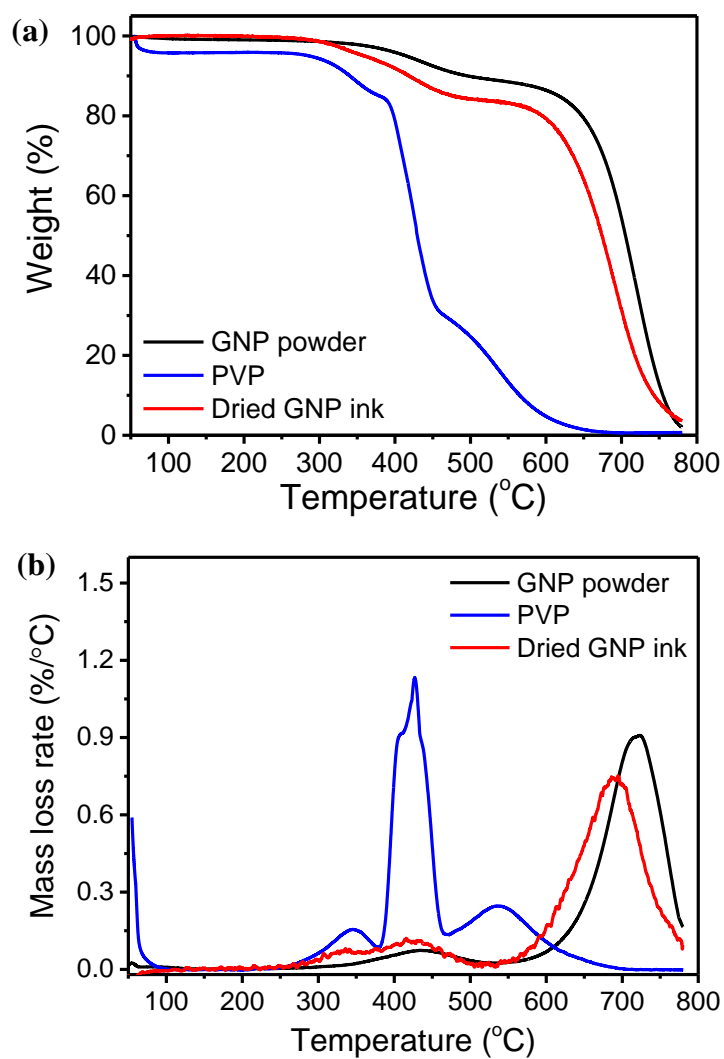


Figure S4. Thermal gravimetric analysis (TGA) of GNP powder, PVP and 120 °C dried GNP ink, with a heating rate of 10 °C/min in air condition.

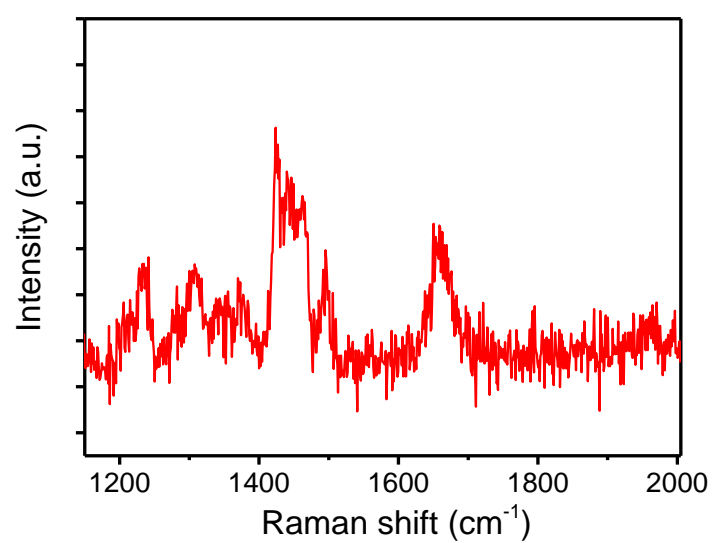


Figure S5. Raman spectrum of a PVP film on a Si/SiO₂ substrate.

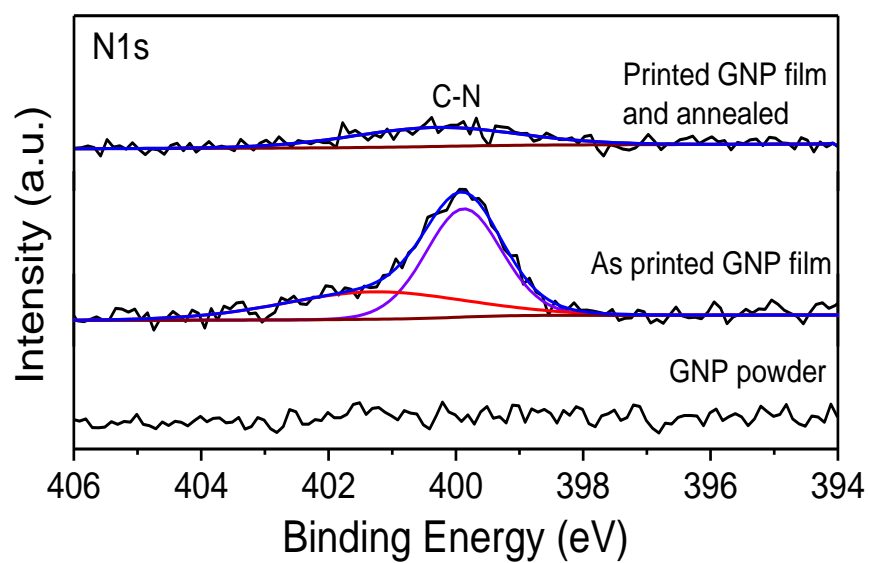


Figure S6. XPS N 1s spectra of GNP powder, as printed graphene film, and printed graphene films after annealing at 350 °C.

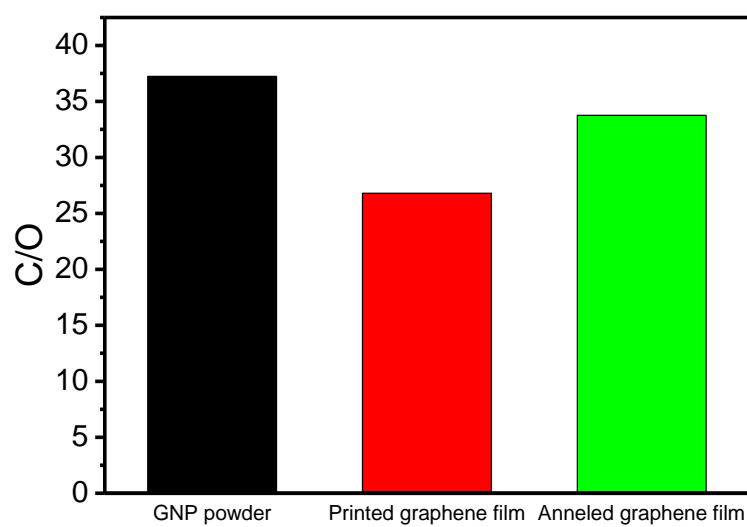


Figure S7. The carbon to oxygen (C/O) ratio of GNP powder, printed graphene film, and printed graphene films after annealing at 350 °C.

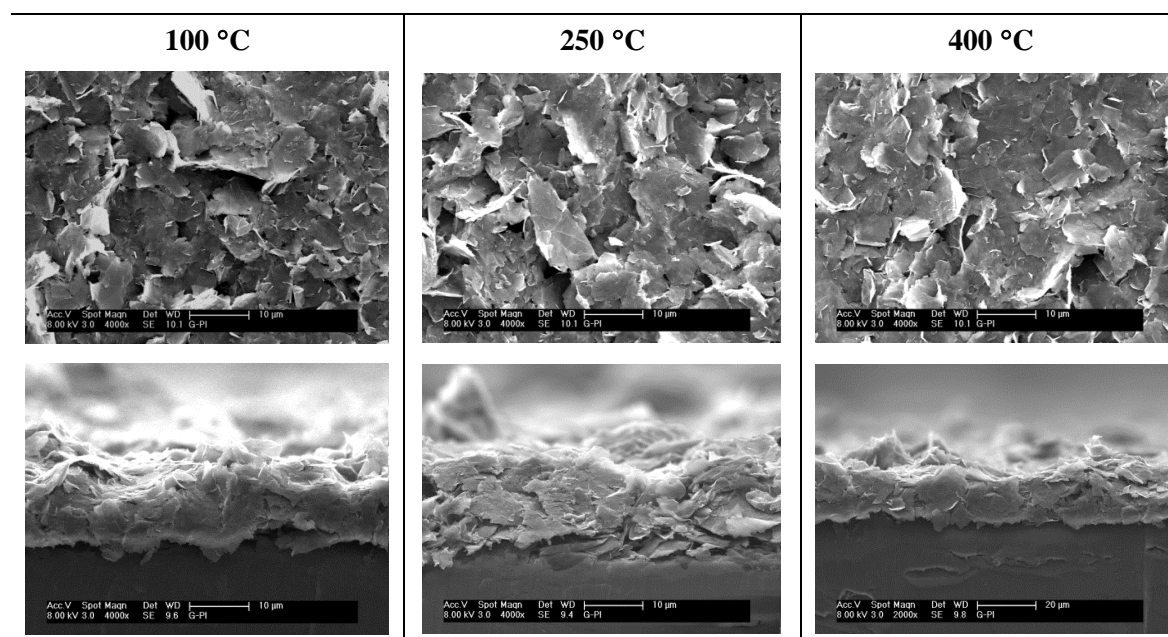


Figure S8. SEM images of printed graphene patterns annealed at different temperatures: surface (plan) view (top) and cross section view (bottom).

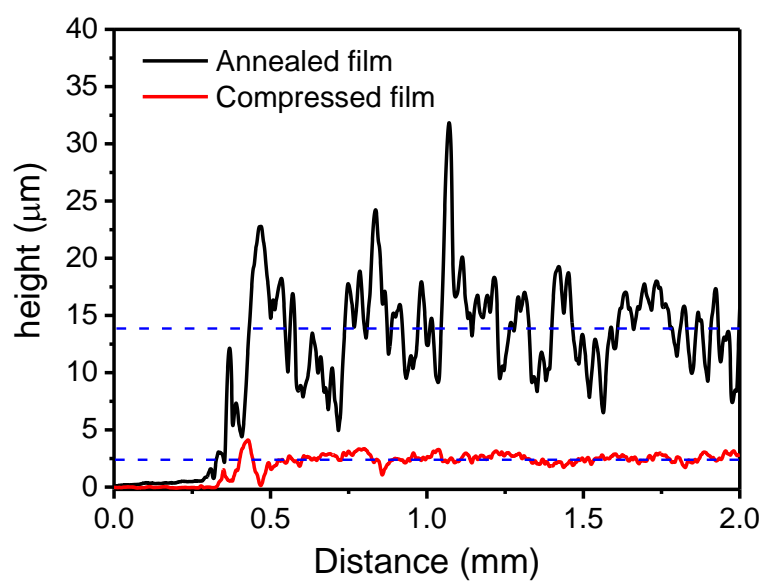


Figure S9. Surface profiles of annealed graphene patterns before and after the rolling compressing process.

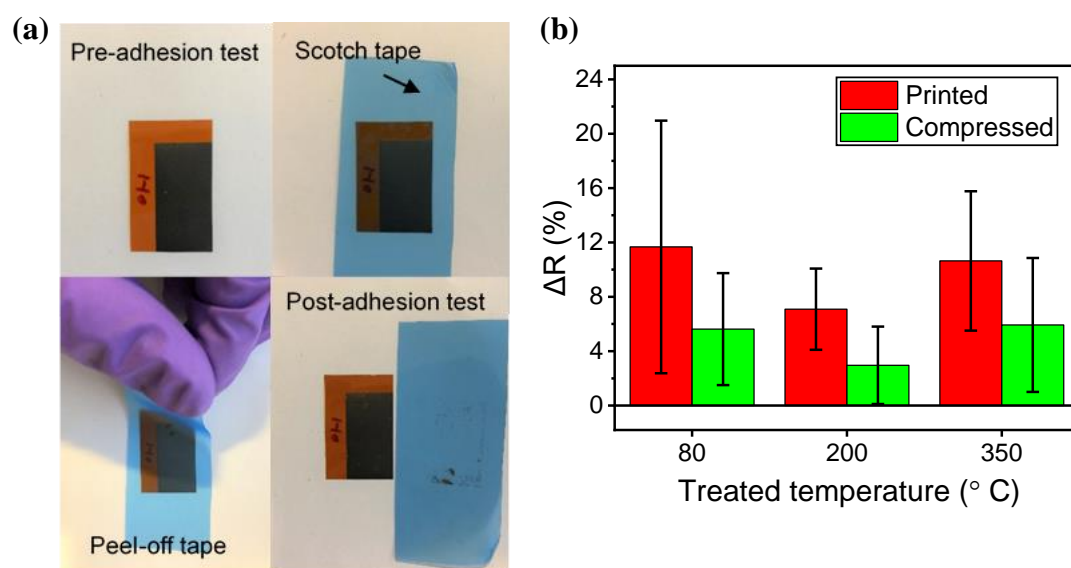


Figure S10. (a) Images of the adhesion test procedures with Scotch tape for printed graphene patterns on PI substrate. (b) Change in the resistance for printed graphene patterns with different treated temperature and compression process after the Scotch tape test on PI substrates.

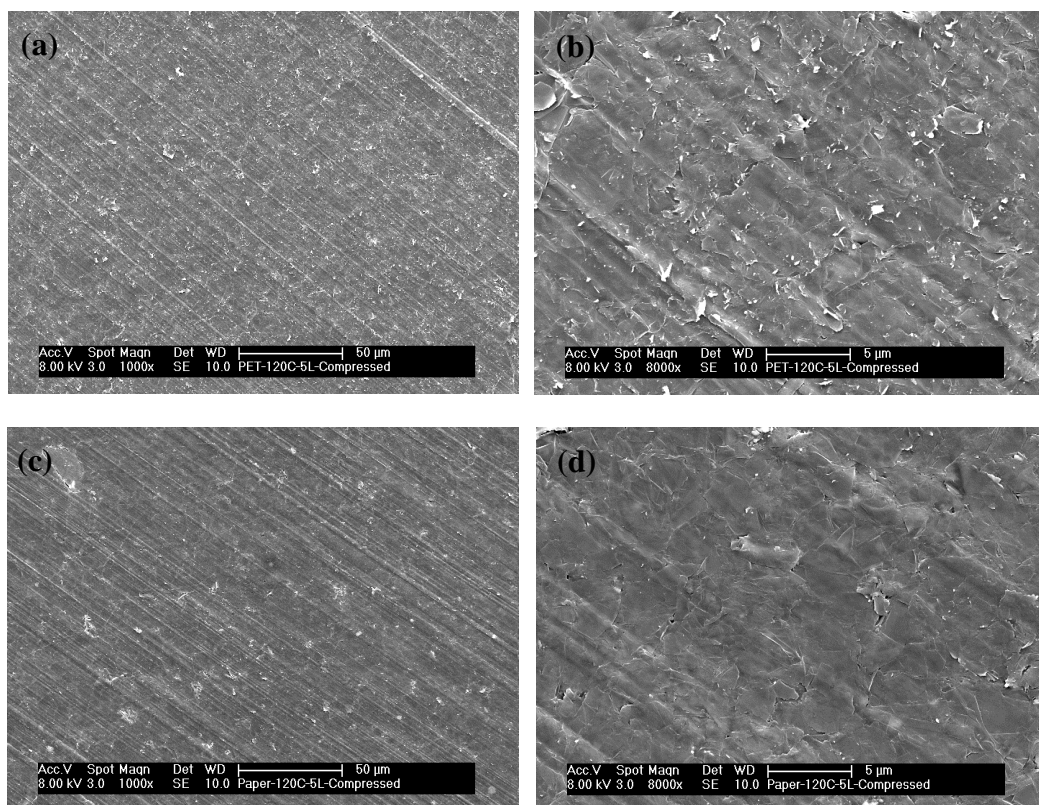


Figure S11. Surface SEM images of printed graphene patterns with 5 printing passes on PET (a, b) and paper (c, d) substrates after the rolling compressing process.

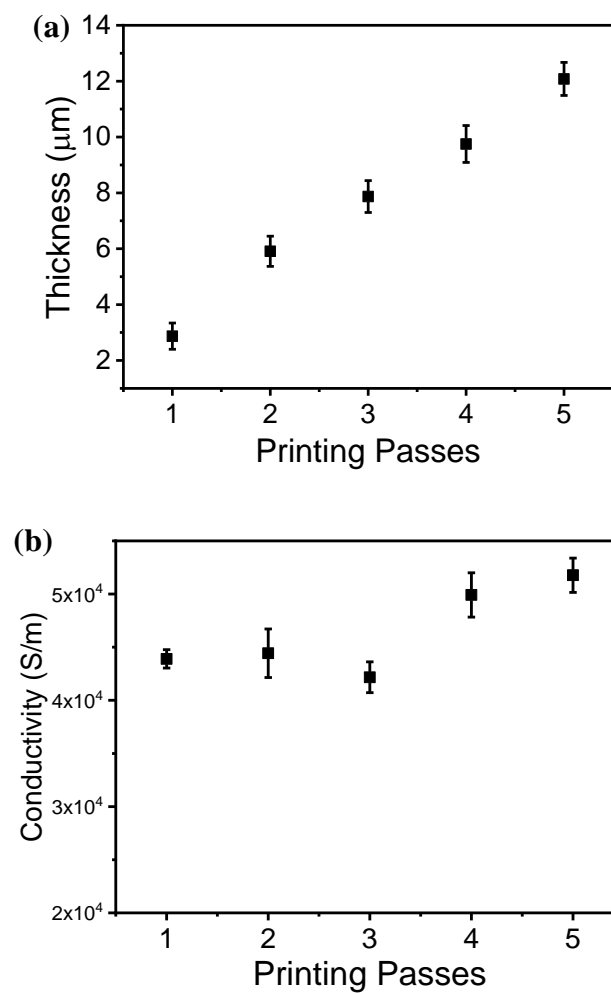


Figure S12. Thickness (a) and electrical conductivity (b) of compressed graphene patterns on PET substrates for increasing numbers of printing passes.

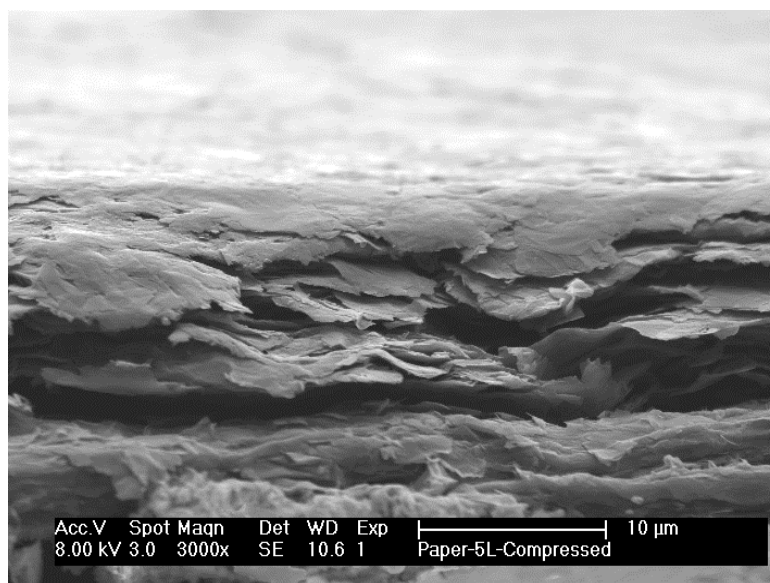


Figure S13. SEM images of cross section of printed graphene patterns with 5 printing passes on paper substrates after the rolling compressing process.

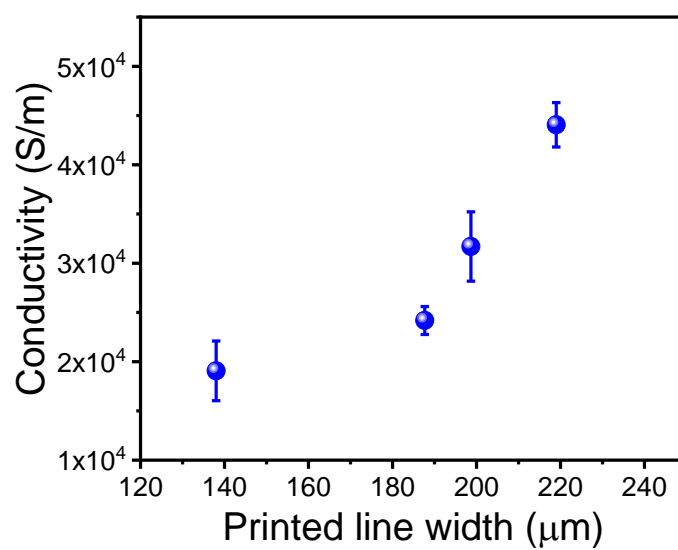


Figure S14. The calculated conductivity of the screen-printed graphene lines with various line widths on PI substrates after annealing at 350 °C and rolling compression process.

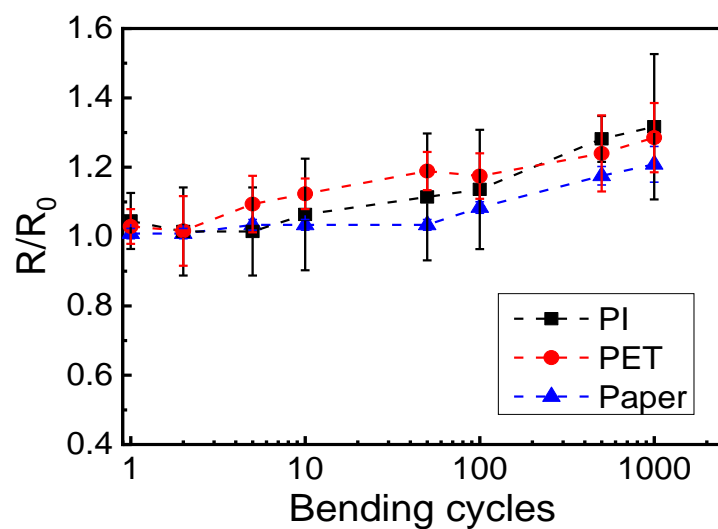


Figure S15. The change of normalized resistance of the screen-printed Ag patterns on flexible substrates (PI, PET and paper) with the increase of bending cycles. The bending tests were conducted at a constant bending radius of 3 mm over a range of bending cycles up to 1000 cycles.

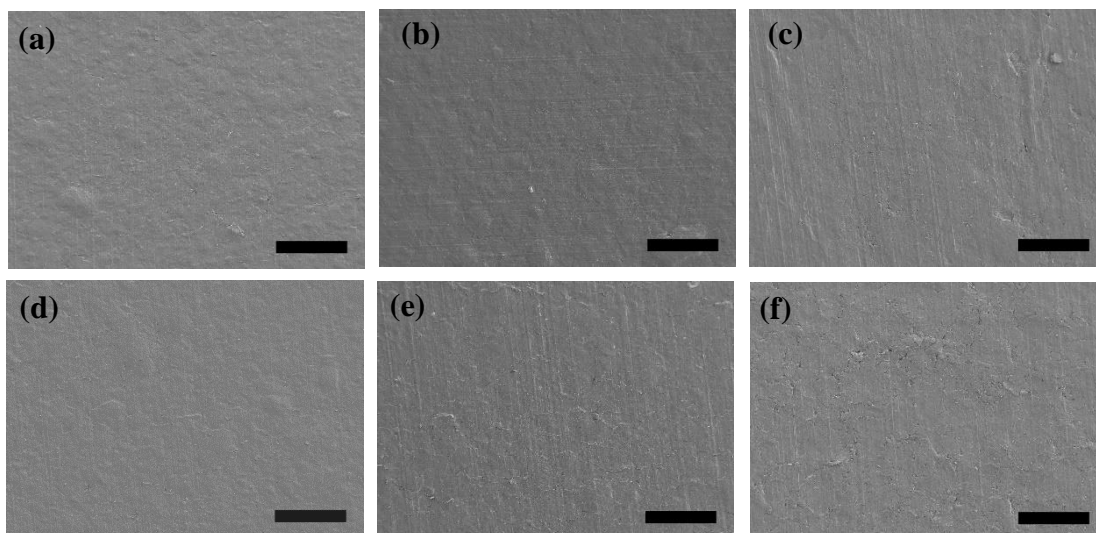


Figure S16. SEM images of the printed graphene pattern before (a-c) and after (d-f) 1,000 bending cycles for PI (a, d), PET (b, e) and paper (c, f) substrates. All scale bars are 50 μm .

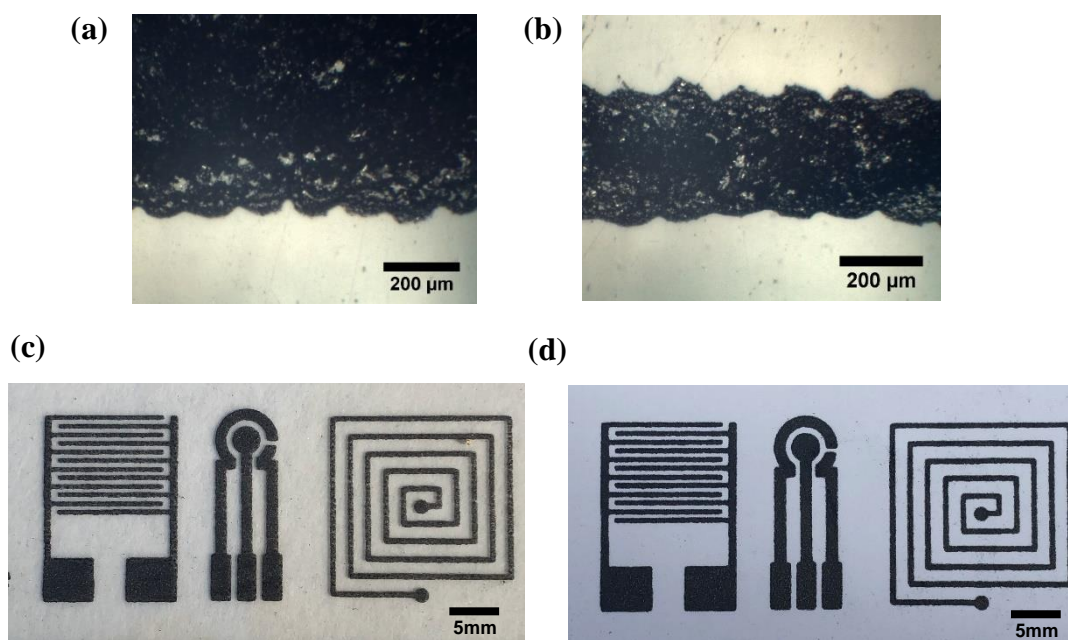


Figure S17. Optical microscope images of (a) edge of printed graphene patterns and (b) a printed line with a width around 300 μm on PET substrates. Images of different printed graphene patterns on (c) PET and (d) paper substrates.

Supplementary Tables

Table S1. Comparison of literature values for the conductivity of printed graphene-based patterns on flexible substrates. Listed in approximately chronological order.

Graphene type	Substrate	Printing	Highest process temperature (°C)	Best electrical conductivity (S/m)	Ref.
C-RGO by ascorbic acid	PET	Inkjet	80	1.5×10^3	1
T-RGO by heating	PI	Inkjet	400	8.74×10^2	2
C-RGO by hydrazine and ammonia vapour	PET	Inkjet	90	3.5×10^4	3
C-RGO by hydrazine and ammonia vapour	PVDF	Inkjet	90	5.5×10^3	4
T-RGO by IR heat lamp	PI	Inkjet	200	8×10^2	5
C-RGO by HI vapour	PET	Inkjet	100	4.2×10^4	6
Ethanol and EC exfoliated	PI	Inkjet	250	2.5×10^4	7
DMF exfoliated	PI	Inkjet	400	3.4×10^3	8
Lithium-THF expanded graphite	Paper	Inkjet	50	1×10^3	9
Supercritical CO ₂ exfoliated	PI	Inkjet	300	9.24×10^3	10
NMP exfoliated	Paper	Inkjet	70	3×10^3	11
Ethanol and EC exfoliated	PI	Gravure	250	$\sim 1 \times 10^4$	12
Ethanol and EC exfoliated	PI	Screen	300	1.86×10^4	13
NMP exfoliated	Paper	Screen	100	4.3×10^4	14
Ethanol and EC exfoliated	PI	Inkjet	250	2.56×10^4	15
Lithium-THF exfoliated	PET	Screen	100	$\sim 1.33 \times 10^3$	16
C-RGO by HBr acid	PET	Inkjet	80	4×10^3	17
Lithium-THF exfoliated	PET	Screen	100	2.85×10^4	18
C-RGO by HI acid	PET	3D	100	4.51×10^4	19
Microfluidization exfoliated	Paper	Screen	100	$\sim 1 \times 10^3$ *	20
Ethanol and EC exfoliated	PI	Inkjet	350	$\sim 4 \times 10^4$	21
IPA and PVP exfoliated	PI	Inkjet	400	$\sim 1 \times 10^4$	22
Graphene nanoplatelets	PET	Screen	120	$\sim 5.18 \times 10^4$	This work
	PI		350	$\sim 8.81 \times 10^4$	

*The conductivity (σ) is calculated from the data of sheet resistance (R_s) and thickness (t) supported in the paper through the equation: $\sigma = 1/(R_s \times t)$.

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