Supporting Information

COMMUNICATION

Fabrication of high-performance flexible photodetectors based on Zn-doped MoS_2/graphene hybrid fibers

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Experimental Section

Preparation of GO thin film and GO fibers

Graphene oxide (GO) was synthesized from natural graphite via a modified Hummer's method. Natural graphite flakes (Sigma Aldrich) were oxidized using $NaNO_3$, H_2SO_4, $KMnO_4$, and H_2O_2, and the as-synthesized GO was washed several times by centrifugation. The GO sheets were exfoliated by ultra-sonication. GO solution (20 mg) in 20 ml distilled water was spin-coated onto a SiO_2 substrate at 2000 rpm for 30s to prepare GO film. The reduced GO film was formed by heating at 600°C with a flow of Ar for 5 mins. For the preparation of GO fiber, a glass pipe with an inner diameter of 1.5 mm was utilized. The GO solution with a high concentration was injected into the glass pipe, which was then sealed at both ends with polyimide tape and heated to 80°C for 12 h. Water was then injected into the pipe to delaminate rGO fibers.

CVD Growth of MoS_2 Layer on GO thin film and GO fibers

A layer of *p*-THPP was deposited on the GO layer and GO fibers by thermal evaporation, and metalation of the *p*-THPP layer was carried out by introducing diethylzinc (DEZ) as a metal precursor in the atomic layer deposition (ALD) process. The Mo solution was prepared by dissolving 0.1 M ammonium heptamolybdate (Fluca, 99%) in 10 mL of distilled water. The solution was coated onto SiO_2 substrates by spin-coating at 2,000 rpm for 30 s. 0.1 g of sulfur powder (SAMCHUN, 98.0%) as the sulfur source was located upstream in the reactor. The distance between the sulfur and Mo sources was 19 cm. MoS_2 nanosheets were synthesized at 600°C under ~2 Torr while introducing Ar gas (500 sccm) for 5 min.

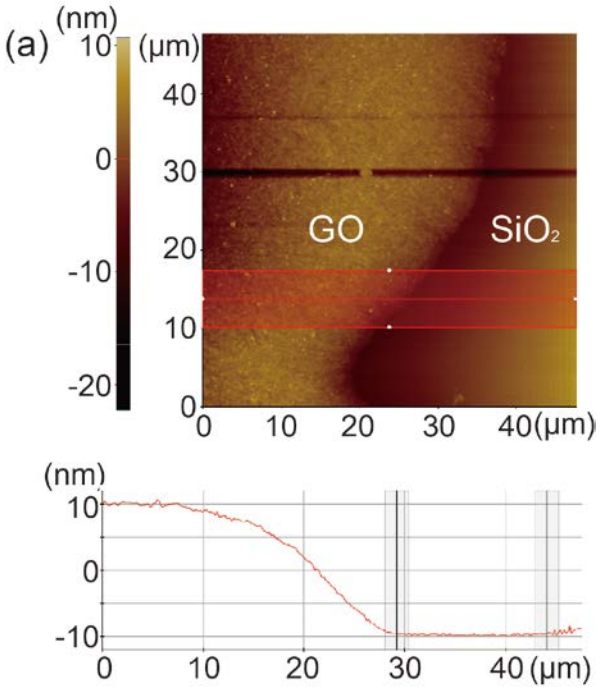

Figure S1. (a) AFM image of GO film spin-coated (2 cycles) on SiO_2

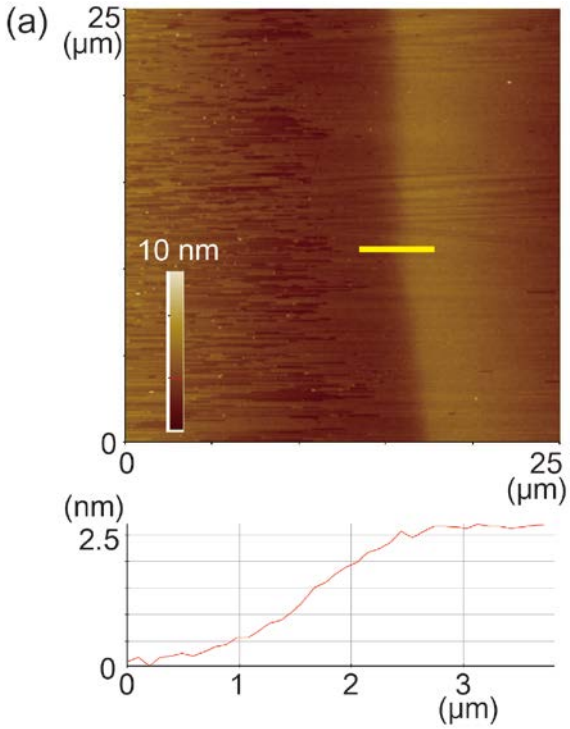

Figure S2. AFM image of the spin-coated *p*-THPP layer.

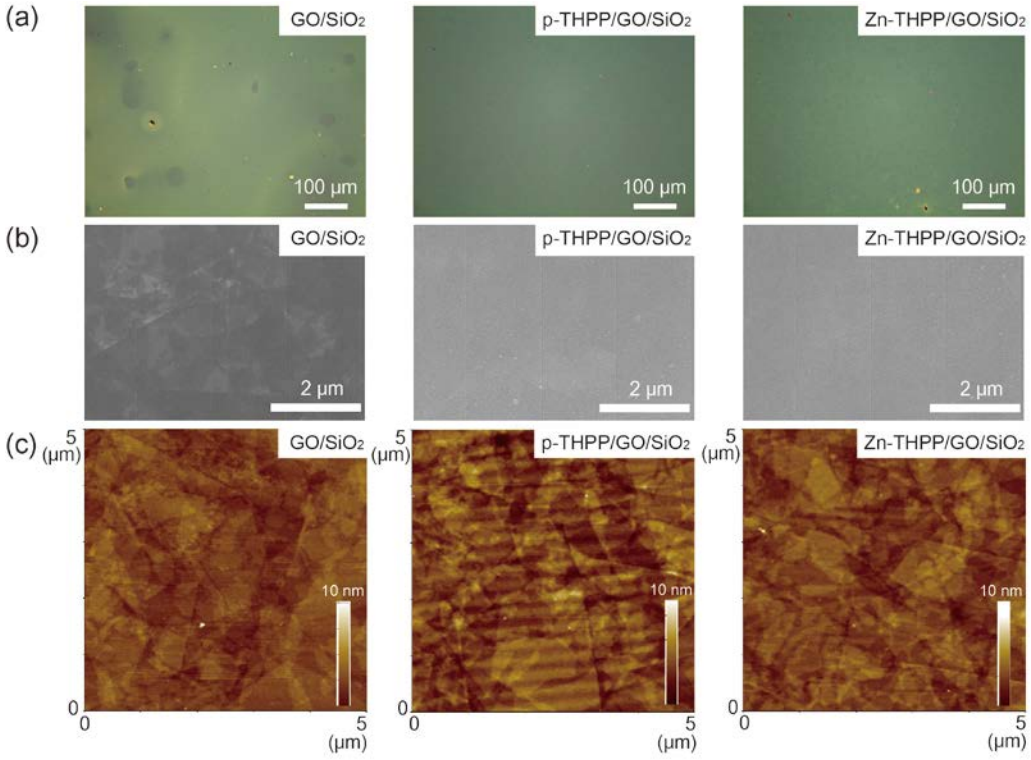

Figure S3. (a) Optical, (b) SEM, and (c) AFM images of GO/SiO_2, *p*-THPP/GO/SiO_2, and Zn-THPP/SiO_2, respectively.

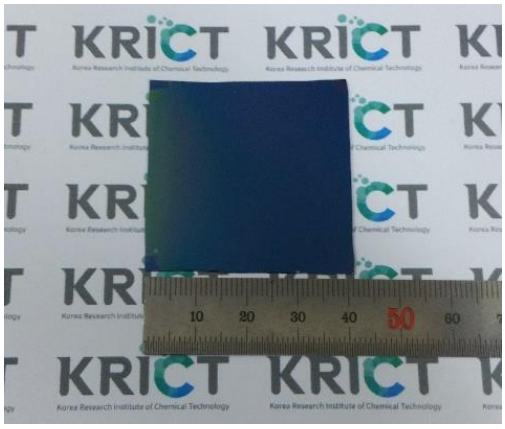

Figure S4. Photograph of as-grown MoS_2 nanosheets on rGO film (4 x 4 cm^2).

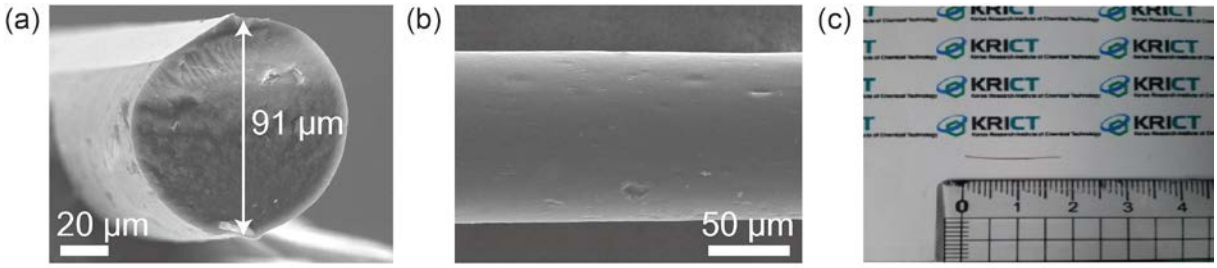

Figure S5. (a) Cross-section SEM image of as-fabricated GO fiber. (b) Top view SEM image of as-fabricated GO fiber. (c) Real image of as fabricated GO fiber.

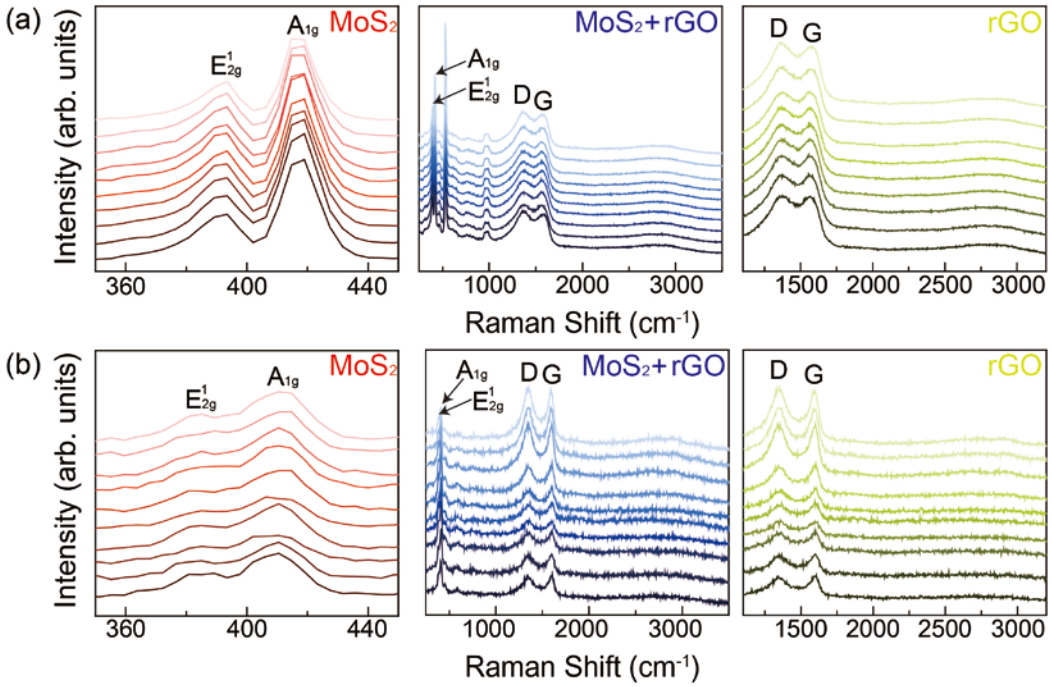

Figure S6. Raman spectra recorded from different positions of on (a) Zn-doped MoS_2 on rGO TF, and (b) Zn-doped MoS_2 on rGO fiber.

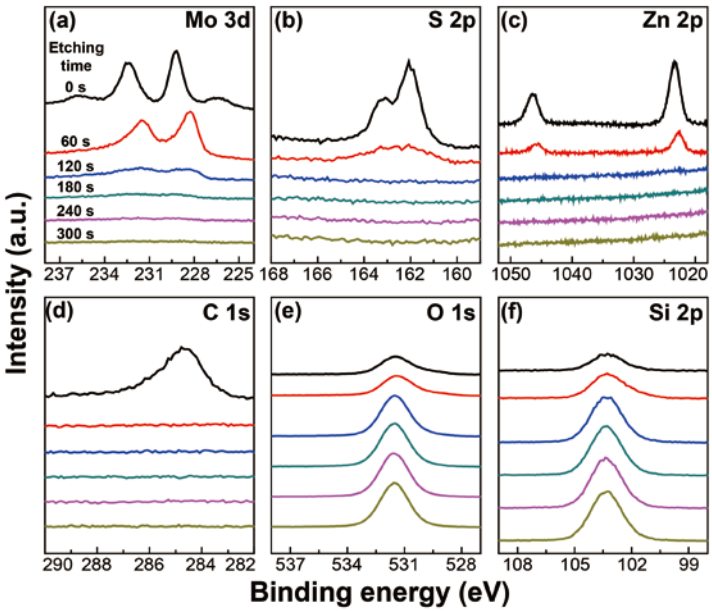

Figure S7. XPS depth profiles of the (a) Mo 3d, (b) S 2p, (c) Zn 2p, (d) C 1s, (e) O 1s and (f) Si 2p core level spectra for Zn-doped MoS_2 film as a function of etching time.

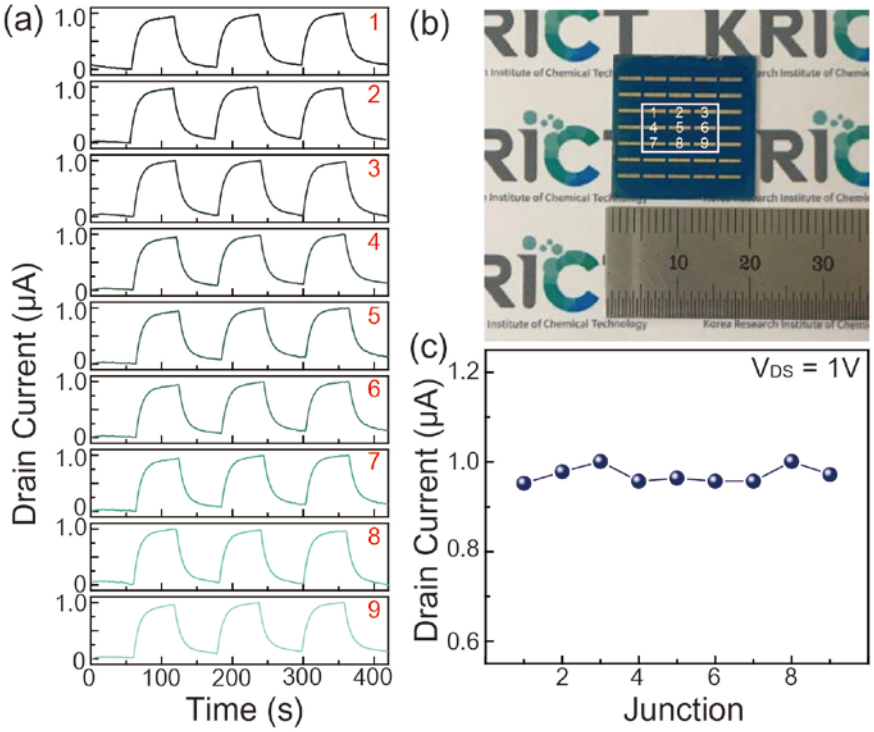

Figure S8. (a) Photoresponse characteristics of the device based on the Zn-doped MoS_2–rGO (DEZ injection time : 80 s) over 9 junctions, (b) photograph showing 9 junctions in the Zn-doped MoS_2–rGO/SiO_2-based device, and (c) plot of the drain current of junctions under light illumination.

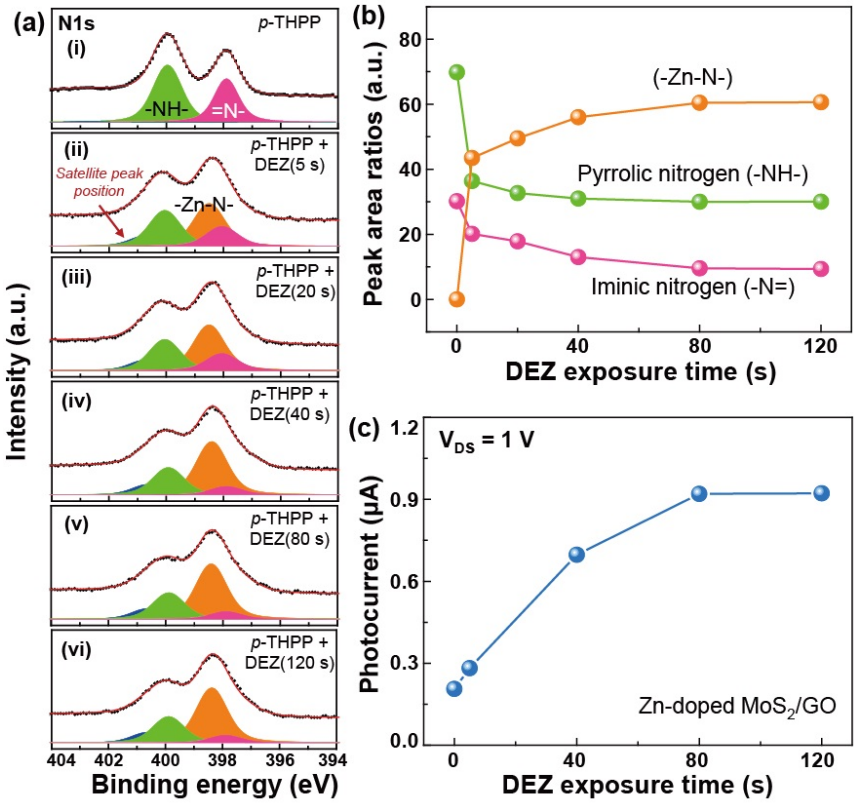

Figure S9. (a) XPS spectra of N 1s core level for (i) p-THPP thin films, Zn(II)THPP thin films formed by introducing Zn precursor for (ii-vi) 5, 20, 40, 80, and 120 s. (b) Plots for the peak area ratios of -NH-, -N= and -Zn-N- extracted from N 1s core level spectra as a function of DEZ exposure time. (c) The photocurrent of the devices based on Zn-doped MoS_2/GO nanosheets as a function of DEZ exposure time.

Table S1. Photodetector performance for the Zn-doped MoS_2/graphene hybrid fibers to other references.

	Year	Wavelength (nm)	Bias voltage (V)	Power density	Responsivity (A/W)
Ref. 1	2014	632.8 nm	0.1 V	0.645 uW/cm^2	10^4 mA/W
Ref. 2	2014	850 nm	0.1 V	1 mW/cm^2	8 mA/W
Ref. 3	2015	1440 nm	2 V	0.4 mW/cm^2	1.26 A/W
Ref. 4	2016	514 nm	-2 V	3 mW/cm^2	~25 mA/W
Ref. 5	2017	540 nm	5 V	0.1 mW/cm^2	40 mA/W
Our work	2017	visible	2 V	125.2 W/m^2	5.73A/W

Ref. [S1] H. Xu, J. Wu, Q. Feng, N. Mao, C. Wang and J. Zhang, *Small*, 2014, **10**, 2300-2306.

Ref. [S2] C. G. Kang, S. K. Lee, T. J. Yoo, W. Park, U. Jung, J. Ahn and B. H. Lee, *Appl. Phys. Lett.* 2014, **104**, 161902.

Ref. [S3] P. Vabbina, N. Choudhary, A.-A. Chowdhury, R. Sinha, M. Karabiyik, S. Das, W. Choi and N. Pala, *ACS Appl. Mater. Interfaces,* 2015, **7**, 15206-15213.

Ref. [S4] A. Midya, A. Ghorai, S. Mukherjee, R. Maiti and S. K. Ray, *J. Mater. Chem. A,* 2016, **4**, 4534-4543.

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