Supplementary Information:

Effect of GO additive in ZnO/rGO nanocomposites with enhanced photosensitivity and photocatalytic activity

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Table S1 Comparisons of photosensitivity and time-dependent photocurrent response between the present work and other reported UV detectors.

Structure	Substrate	λ_{UV} (nm)	UV intensity (W/cm^2)	Bias voltage (V)	Dark current (A)	Photosensitivity (I_{UV}/I_{DARK})	Response time (s)	Ref.
MgZnO/ZnO thin film	Glass	365	3.20×10^{-3}	4	$\sim 4.64 \times 10^{-6}$	~1.01	-	[1]
ZnO nanowires	SiO_2/Si	325	0.42×10^{-3}	1.5	$\sim 0.50 \times 10^{-6}$	<4	-	[2]
ZnO nanowires	SiO2/Si	300	2×10^{-3}	0.1	$\sim 12.70 \times 10^{-6}$	~1.51	0.2	[3]
	SiO_2/Si	500	19.50×10^{-3}	0.1	$\sim 12.50 \times 10^{-6}$	~1.40	0.3	[3]
ZnO nanostructures	p-Si	365	0.80	3	$\sim 3.50 \times 10^{-6}$	~1.71	-	[4]
Ti-doped ZnO thin film	glass	~365	2×10^{-3}	5	$\sim 15.00 \times 10^{-9}$	~6.80	135	[5]
ZnO/rGO nanostructures	glass	365	0.80×10^{-3}	2	$\sim 7.00 \times 10^{-6}$	4	44	[6]
ZnO/GO nanostructures	glass	368	0.80×10^{-3}	4	-	20.10	-	[7]
ZnO/rGO (20%)	transparent film	365	0.62×10^{-3}	2	3.98×10^{-9}	8.81	18.16	This work

Table S2 Comparisons of photocatalytic activity between the present work and other reported research.

Catalyst	Catalyst concentration ($g\ L^{-1}$)	Light source	MB concentration ($mg\ L^{-1}$)	Degradation rate (%) and time (min)	k_c (min^{-1})	Ref.
ZnO/GO (3%)	0.4	Metal halide lamp	10	~92% / 30	0.042	[8]
ZnO-g-C_3N_4/GO (50%)	0.3	Visible light	10	99% / 90	0.030	[9]
GO/ZnO (1:2)	0.4	UV light (254 nm)	5	94.5% / 60	-	[10]
ZnO/rGO (2.5%)	0.5	Mercury lamp (310-400 nm)	10	~80% / 120	0.012	[11]
ZnO NPs/rGO	0.3	Hg lamp (365 nm)	10	99.5%/ 180	-	[12]
ZnO/rGO	0.1	Mercury lamp (365-366 nm)	10	83%/ 10	-	[13]
ZnO/rGO	0.15	Hg lamp (365 nm)	5	88%/ 260	-	[14]
ZnO/rGO (1.5%)	0.2	Natural sunlight	5	82.3% / -	-	[15]
ZnO/g-C_3N_4 (500 ℃)	0.2	4 - Visible-light lamps (545 nm)	10	~99% / 180	~0.033	[16]
ZnO/rGO (20%)	0.2	Fluorescent lamp	10	93.78% / 60	0.0482	This work

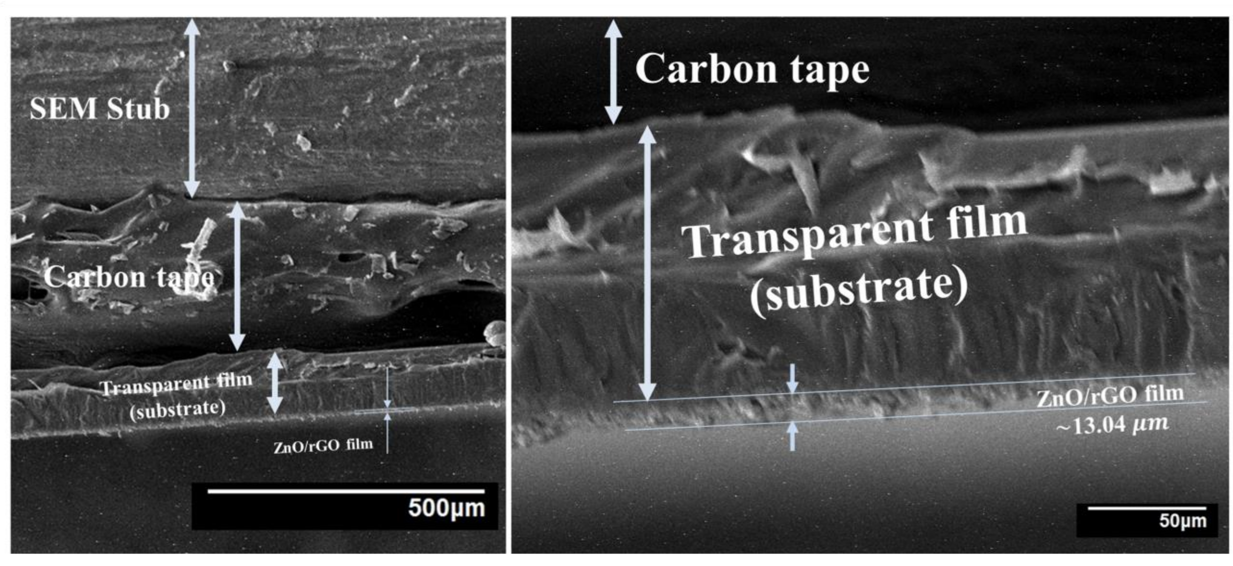

Figure S1. The thickness of prepared films by spray coating

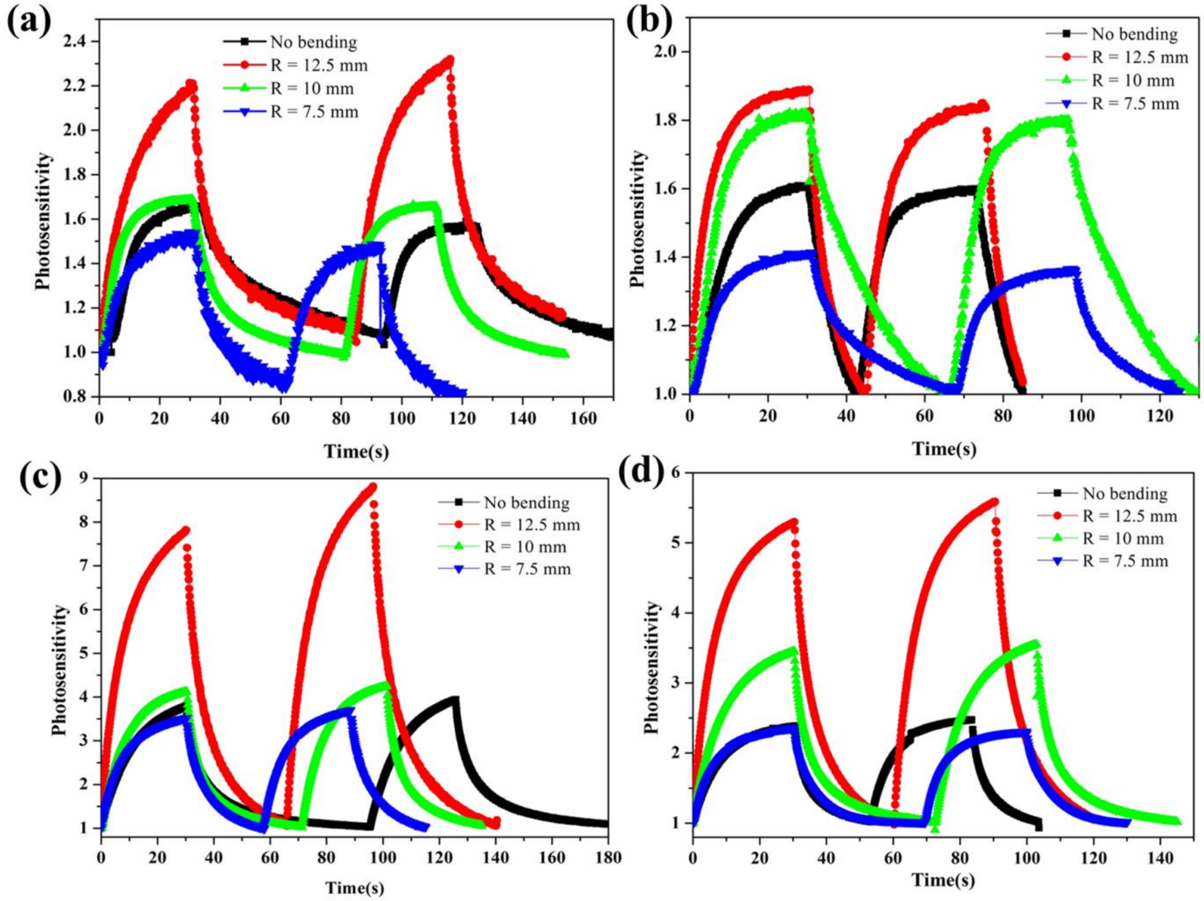

Figure S2. Current of as-synthesized ZnO/rGO with bending radius; **(a)** ZnO, **(b)** ZnO/rGO (10%), **(c)** ZnO/rGO (20%), and **(d)** ZnO/rGO (30%).

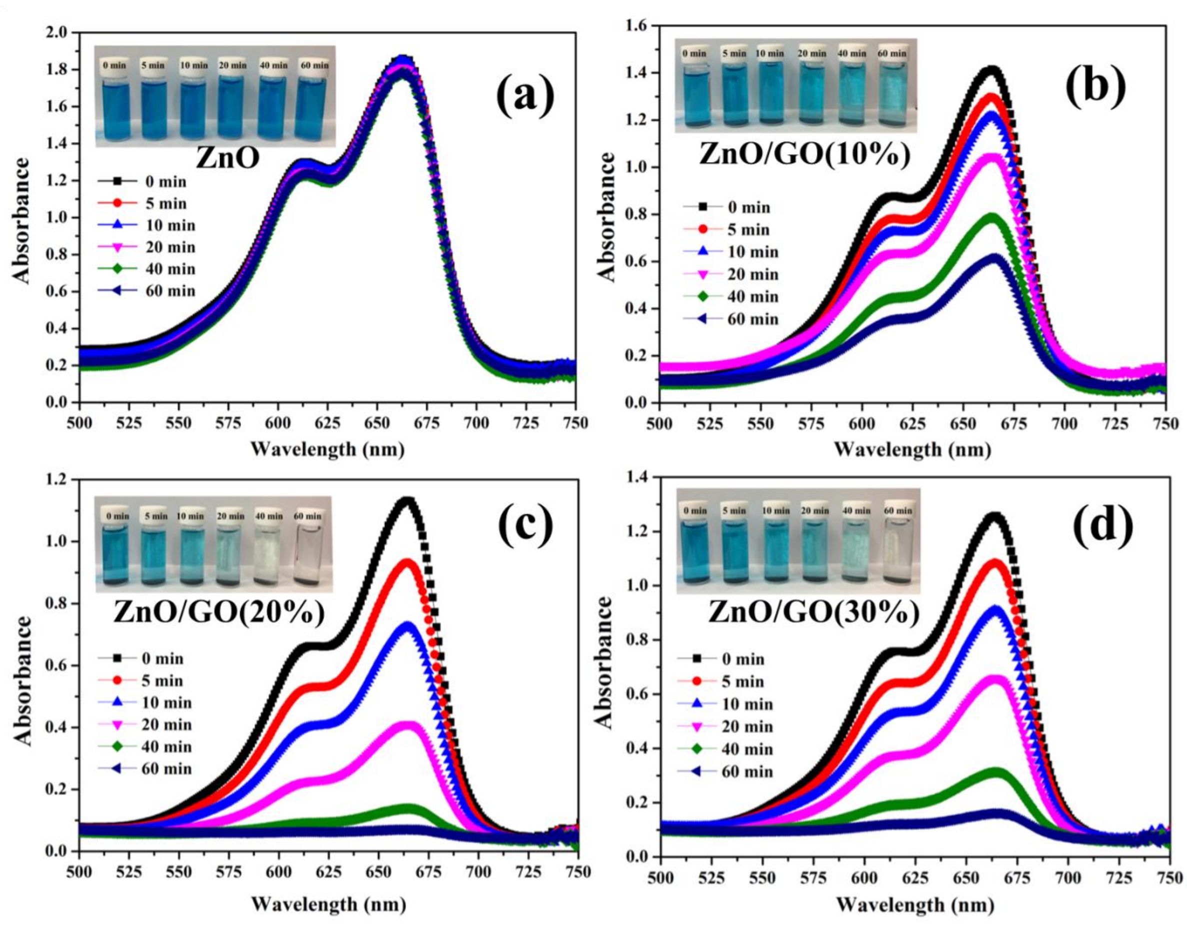

Figure S3. Time-dependent absorption spectra of Methyl blue (MB) solution under visible light using **(a)** ZnO, **(b)** ZnO/rGO (10%), **(c)** ZnO/rGO (20%), and **(d)** ZnO/rGO (30%) as a photocatalyst.

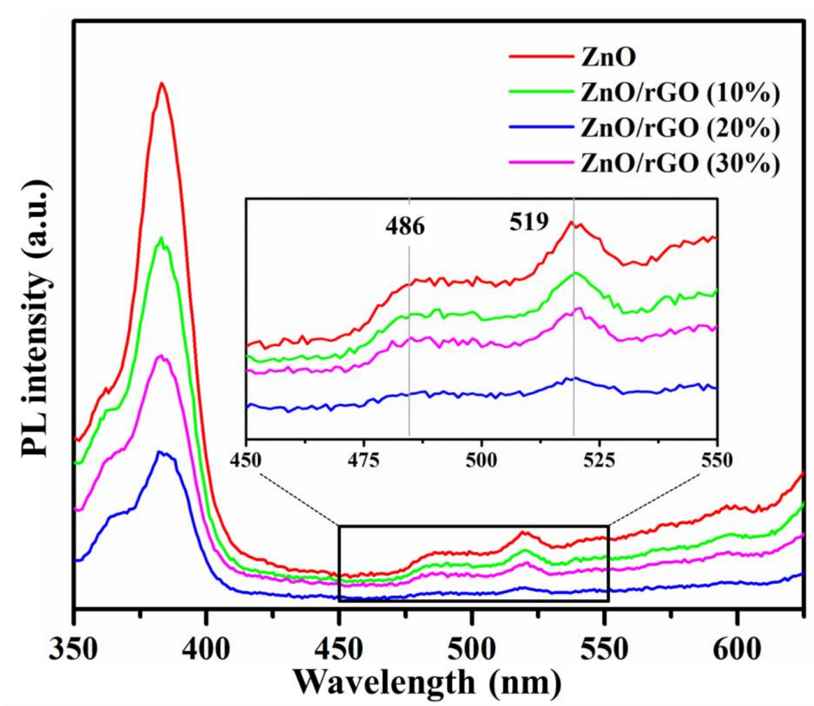

Figure S4. The photoluminescence spectra of pristine ZnO and as-synthesized ZnO/rGO

References

1. Rana, V. S.; Rajput, J. K.; Pathak, T. K.; Purohit, L. P., Multilayer MgZnO/ZnO thin films for UV photodetectors. *Journal of Alloys and Compounds* **2018,** 764, 724-729.
2. Lang, Y.; Gao, H.; Jiang, W.; Xu, L.; Hou, H., Photoresponse and decay mechanism of an individual ZnO nanowire UV sensor. *Sensors and Actuators A: Physical* **2012,** 174, 43-46.
3. Chao, L.-C.; Ye, C.-C.; Chen, Y.-P.; Yu, H.-Z., Facile fabrication of ZnO nanowire-based UV sensors by focused ion beam micromachining and thermal oxidation. *Applied Surface Science* **2013,** 282, 384-389.
4. Bedia, A.; Bedia, F. Z.; Benyoucef, B.; Hamzaoui, S., Electrical Characteristics of Ultraviolet Photodetector based on ZnO Nanostructures. *Physics Procedia* **2014,** 55, 53-60.
5. Shewale, P. S.; Lee, N. K.; Lee, S. H.; Kang, K. Y.; Yu, Y. S., Ti doped ZnO thin film based UV photodetector: Fabrication and characterization. *Journal of Alloys and Compounds* **2015,** 624, 251-257.
6. Safa, S.; Sarraf-Mamoory, R.; Azimirad, R., Investigation of reduced graphene oxide effects on ultra-violet detection of ZnO thin film. *Physica E: Low-dimensional Systems and Nanostructures* **2014,** 57, 155-160.
7. Zare, M.; Safa, S.; Azimirad, R.; Mokhtari, S., Graphene oxide incorporated ZnO nanostructures as a powerful ultraviolet composite detector. *Journal of Materials Science: Materials in Electronics* **2017,** 28, (9), 6919-6927.
8. Qin, J.; Zhang, X.; Xue, Y.; Kittiwattanothai, N.; Kongsittikul, P.; Rodthongkum, N.; Limpanart, S.; Ma, M.; Liu, R., A facile synthesis of nanorods of ZnO/graphene oxide composites with enhanced photocatalytic activity. *Applied Surface Science* **2014,** 321, 226-232.
9. Jo, W.-K.; Clament Sagaya Selvam, N., Enhanced visible light-driven photocatalytic performance of ZnO–g-C3N4 coupled with graphene oxide as a novel ternary nanocomposite. *Journal of Hazardous Materials* **2015,** 299, 462-470.

10. Munawaroh, H.; Sari, P. L.; Wahyuningsih, S.; Ramelan, A. H., The photocatalytic degradation of methylene blue using graphene oxide (GO)/ZnO nanodrums. *AIP Conference Proceedings* **2018,** 2014, (1), 020119.
11. Jabeen, M.; Ishaq, M.; Song, W.; Xu, L.; Maqsood, I.; Deng, Q., UV-Assisted Photocatalytic Synthesis of ZnO-Reduced Graphene Oxide Nanocomposites with Enhanced Photocatalytic Performance in Degradation of Methylene Blue. *ECS Journal of Solid State Science and Technology* **2017,** 6, (4), M36-M43.
12. Azarang, M.; Shuhaimi, A.; Yousefi, R.; Moradi Golsheikh, A.; Sookhakian, M., Synthesis and characterization of ZnO NPs/reduced graphene oxide nanocomposite prepared in gelatin medium as highly efficient photo-degradation of MB. *Ceramics International* **2014,** 40, (7, Part B), 10217-10221.
13. He, J.; Niu, C.; Yang, C.; Wang, J.; Su, X., Reduced graphene oxide anchored with zinc oxide nanoparticles with enhanced photocatalytic activity and gas sensing properties. *RSC Advances* **2014,** 4, (104), 60253-60259.
14. Lv, T.; Pan, L.; Liu, X.; Lu, T.; Zhu, G.; Sun, Z., Enhanced photocatalytic degradation of methylene blue by ZnO-reduced graphene oxide composite synthesized via microwave-assisted reaction. *Journal of Alloys and Compounds* **2011,** 509, (41), 10086-10091.
15. Omar, F. S.; Nay Ming, H.; Hafiz, S. M.; Ngee, L. H., Microwave Synthesis of Zinc Oxide/Reduced Graphene Oxide Hybrid for Adsorption-Photocatalysis Application. *International Journal of Photoenergy* **2014,** 2014, 8.
16. Jung, H.; Pham, T.-T.; Shin, E. W., Interactions between ZnO nanoparticles and amorphous g-C3N4 nanosheets in thermal formation of g-C3N4/ZnO composite materials: The annealing temperature effect. *Applied Surface Science* **2018,** 458, 369-381.