

Supporting Information

Light Trapping in Conformal Graphene/Silicon Nanoholes for High Performance Photodetectors

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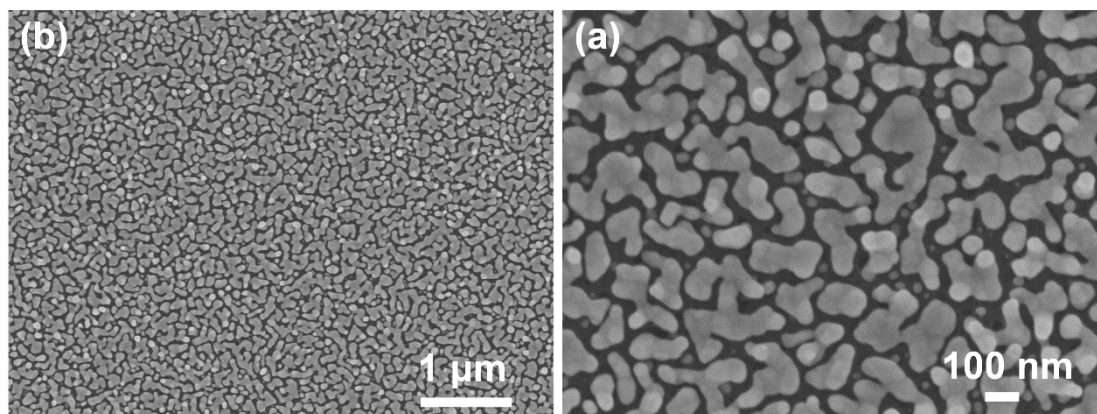


Figure S1. Low (a) and high (b) magnification SEM images of the silver nanoparticles.

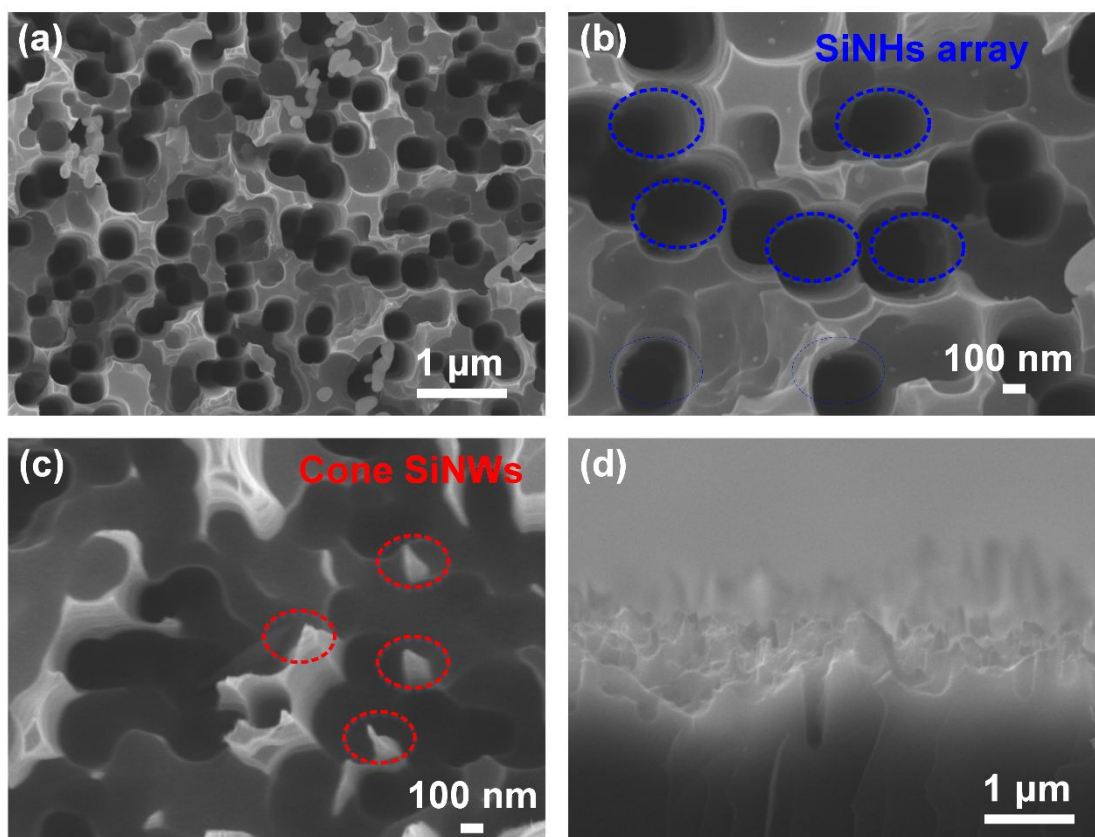


Figure S2. SEM images of silicon nanoholes with low (a) and high (b) magnification,. (c) SEM images of the Si nanocones above the SiNHs arrays; (d) Cross-sectional SEM image of the SiNHs combined with Si nanocones arrays.

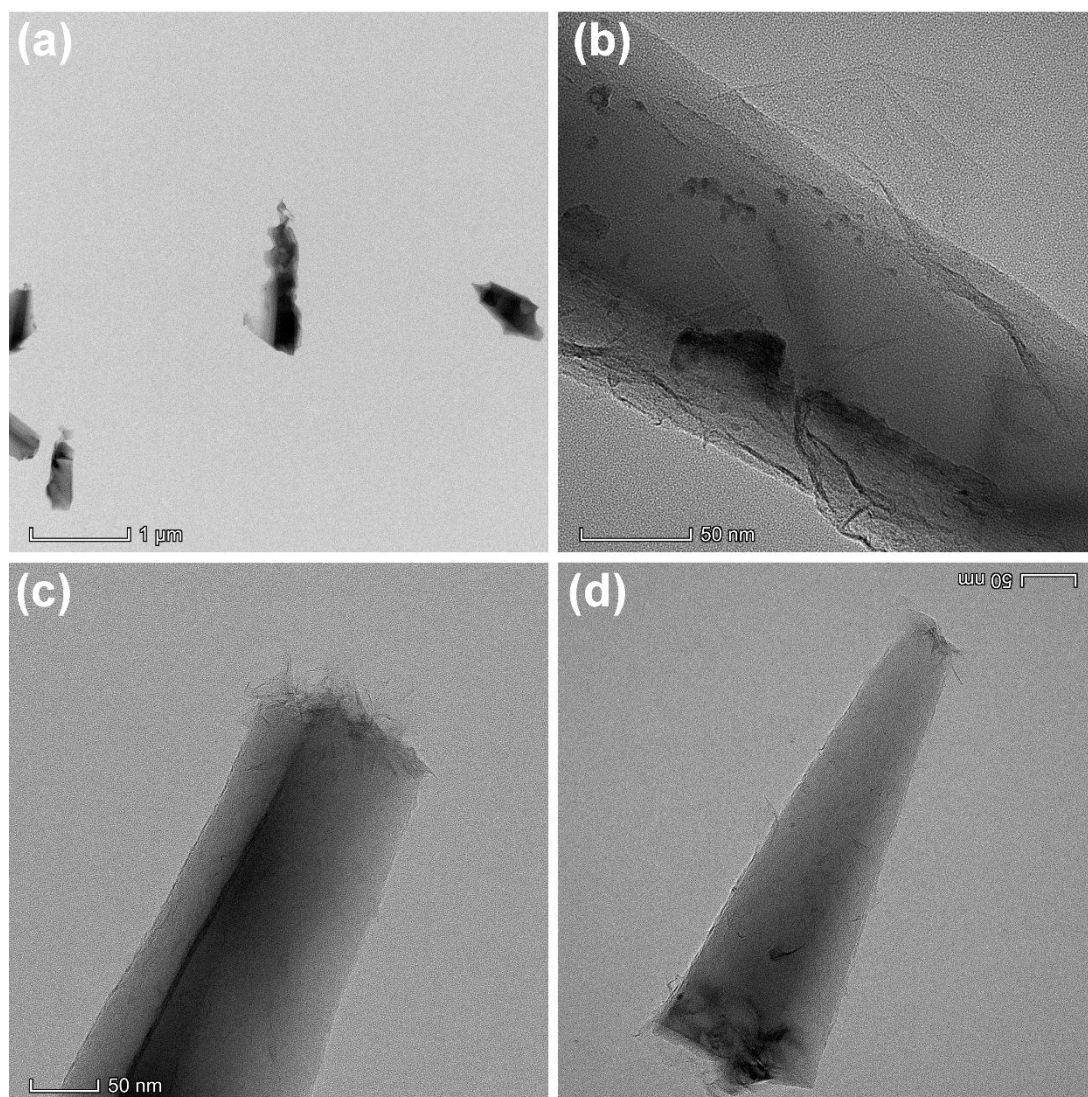


Figure S3. TEM images of graphene on the silicon nanostructures. (a)-(d) TEM samples of the conformal graphene on silicon nanostructures via mechanically scratching.

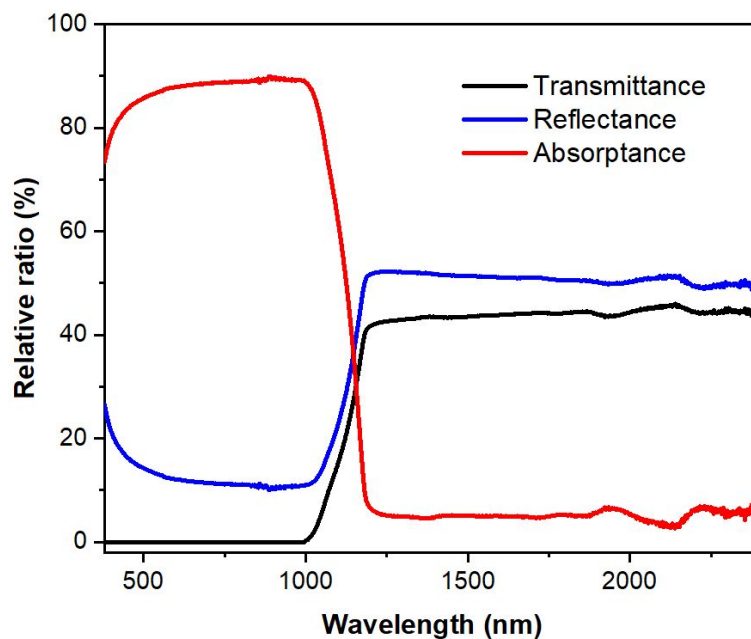


Figure S4. Transmittance, reflectance and absorptance of a SiNHs/Graphene sample.

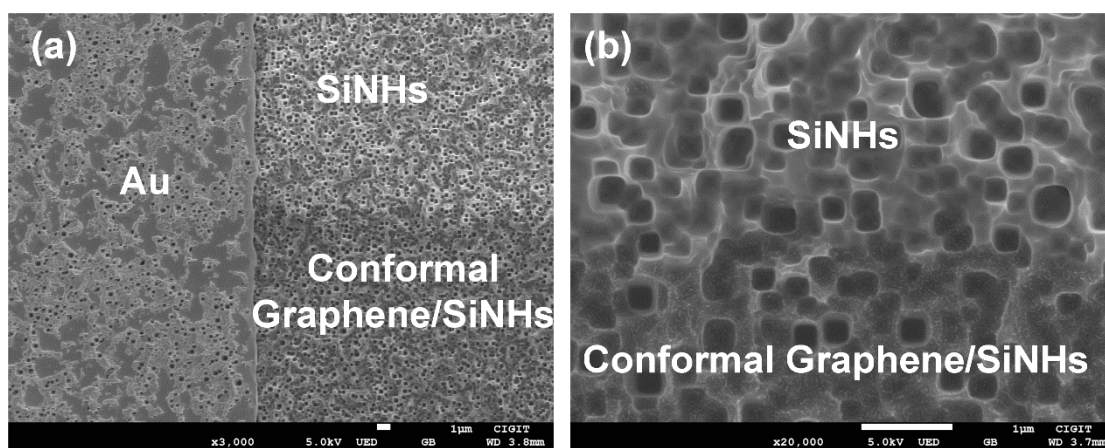


Figure S5. SEM images of the photodetector based on conformal graphene/SiNHs. (a) The neighboring region of the Au electrode, SiNHs substrate and conformal graphene/SiNHs; (b) High-magnification SEM image of the etched conformal graphene on SiNHs substrates.

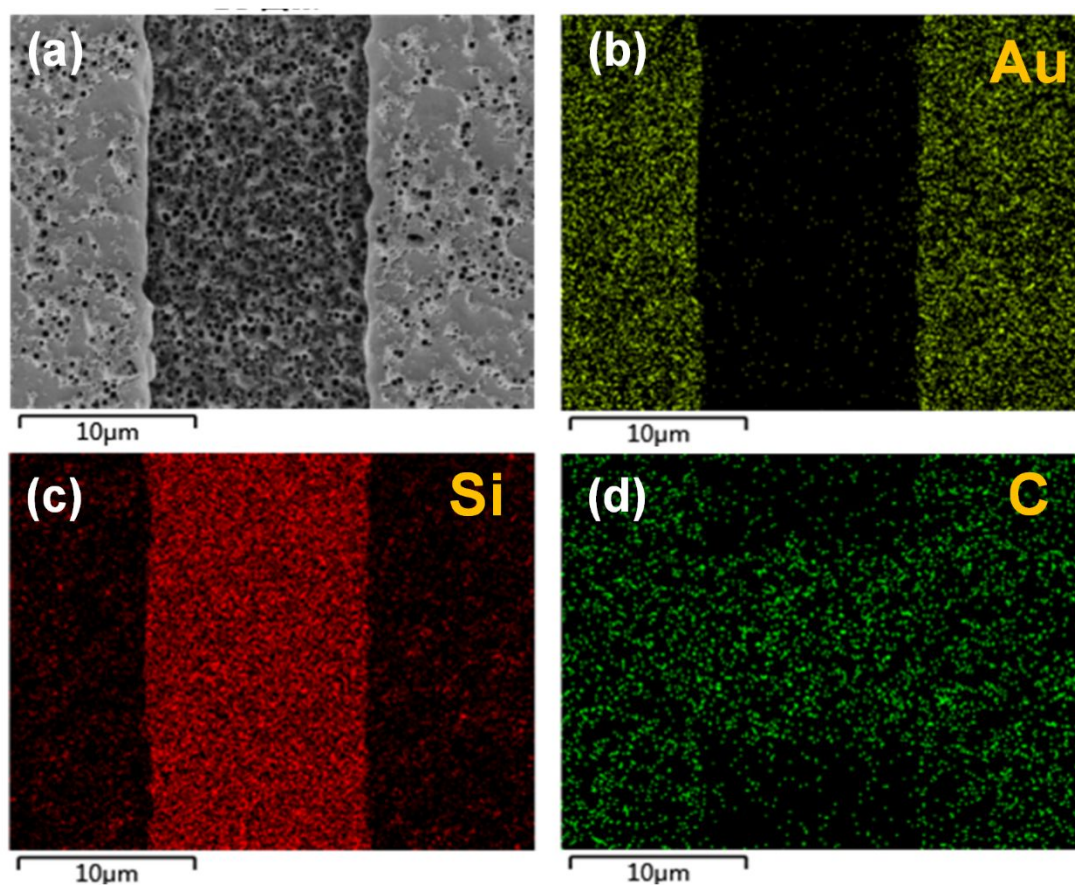


Figure S6. EDS mapping images of the photodetector channel based on conformal graphene/SiNHs. (a) SEM image of the photodetector channel; (b)-(d) Element mapping images of Au, Si and C, respectively.

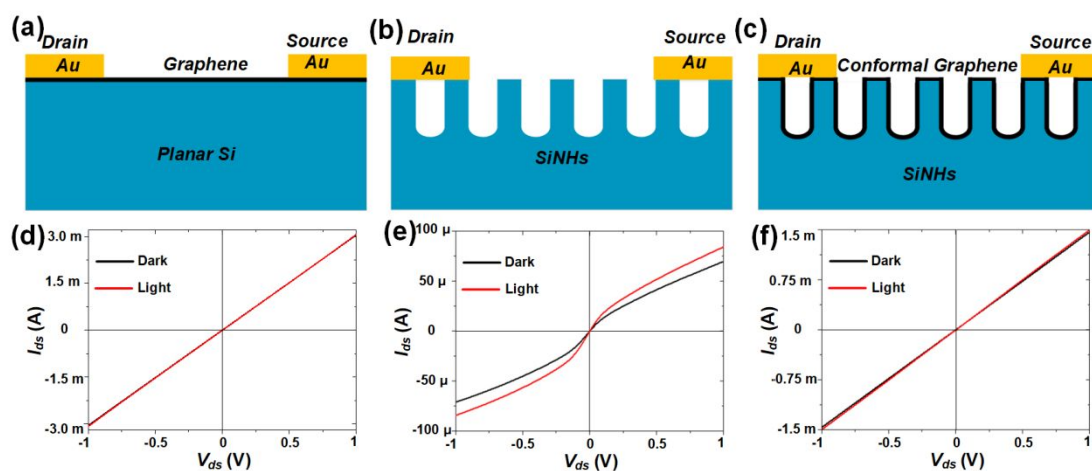


Figure S7. Electrical characteristics of the photodetectors in photoconductor mode. (a)-(c) Schematic diagrams of photodetector based on planar graphene/Si, SiNHs arrays and conformal graphene/SiNHs, respectively. (d)-(f) The I-V curves of photodetectors based on planar graphene/Si detector, SiNHs and conformal graphene/SiNHs.

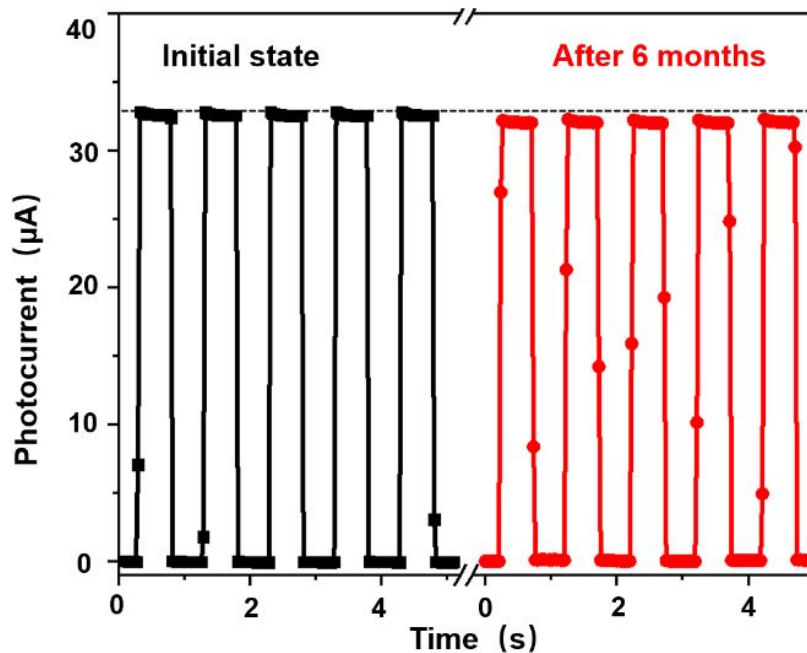


Figure S8. Photoresponse of the conformal graphene/SiNHs photodetector before and after exposing it in air for 6 months.

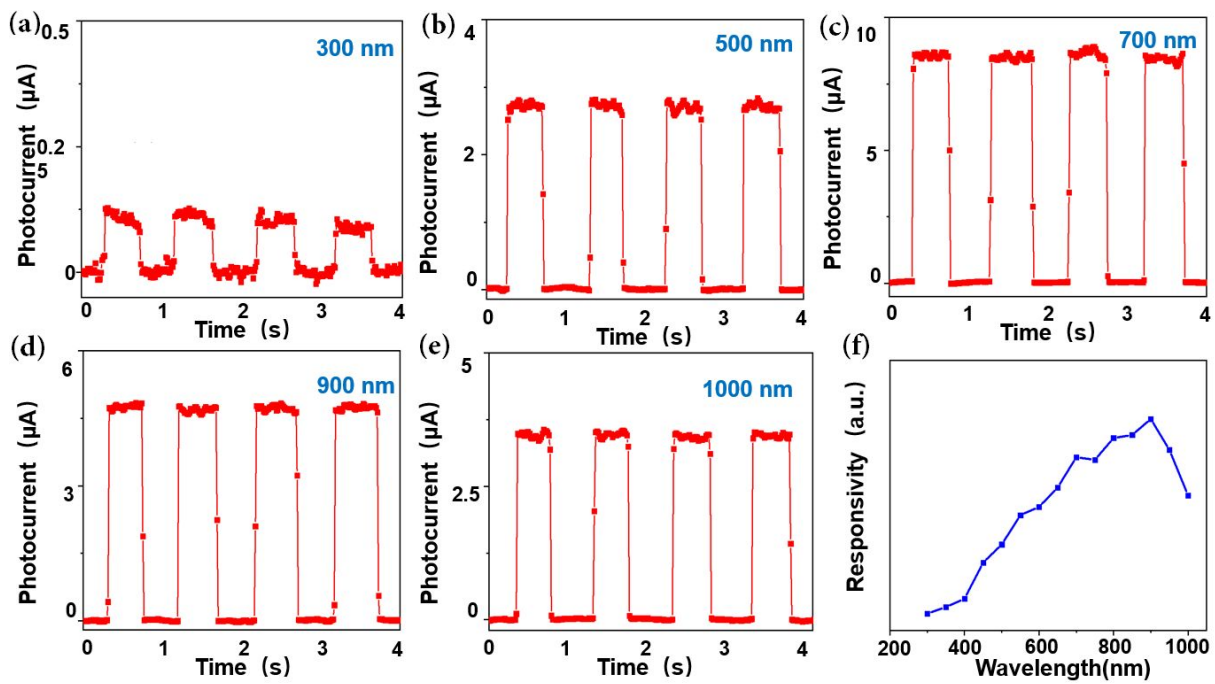


Figure S9. (a)-(e) Photoresponse of the conformal graphene/SiNHs photodetector in the range of 300-1000nm, (f) Normalized responsivity versus wavelength.

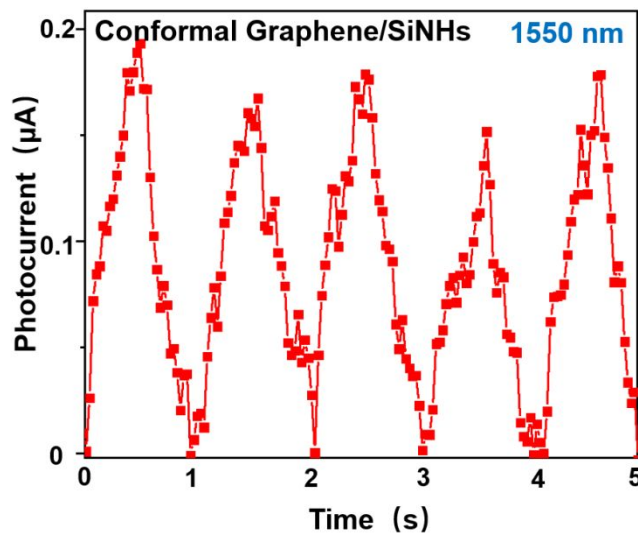


Figure S10. Photoresponse of the conformal graphene/SiNHs detector at 1550 nm.

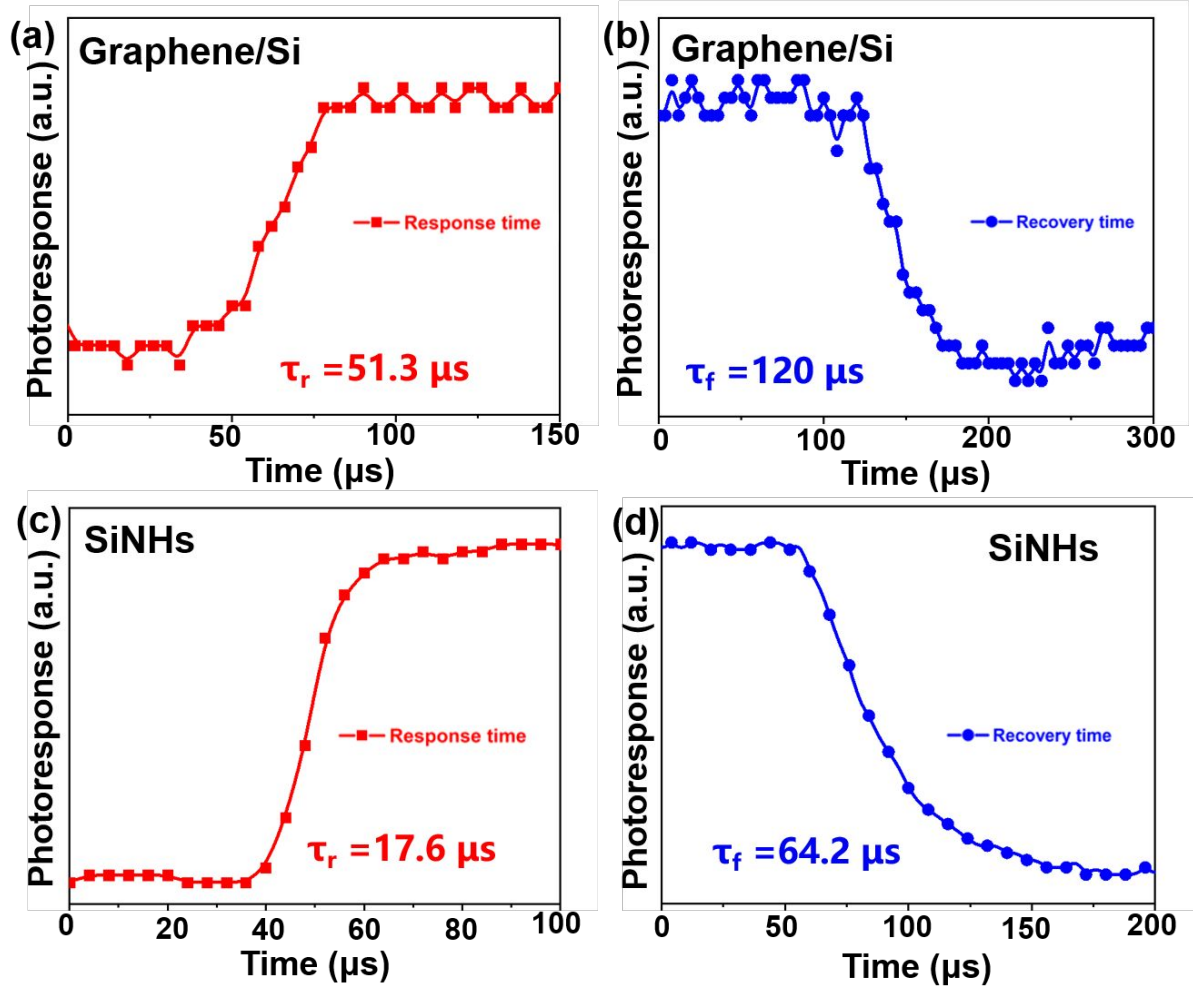


Figure S11. Response speeds of different photodetectors. (a)-(b) Rise time τ_r and recovery time τ_f of the planar graphene/Si based photodetector; (c)-(d) Rise time τ_r and recovery time τ_f of the SiNHs based photodetector.

Table S1 Comparison of Graphene/Si photodetector performance

Device	Mechanism	Responsivity	Response time	Detectivity (cm Hz ^{-1/2} W ⁻¹)	Ref
Graphene/n-Si	Photoconductive	10 ⁶ ~10 ⁷ A/W	1.8 ms	-	1
Graphene/SiO ₂ /n-Si	Photoconductive	1000 A/W	400 ns	1.1×10 ¹⁰ (Measured)	2
Graphene/p-Si	Photoconductive	10 ⁴ A/W	6 μs	-	3
Graphene/Si on insulator	Photovoltaic	0.23 A/W	20 ns	7.83×10 ¹⁰ (Measured)	4
Graphene nanowalls/n-Si	Photovoltaic	0.52 A/W	40 μs	5.88×10 ¹³ (Measured)	5
Conformal graphene/SiNHs	Photoconductive	2720 A/W	6.2 μs	1.25×10¹¹ (Calculated)	Our work

Reference

- (1) Liu, F.; Kar, S. Quantum Carrier Reinvestment-Induced Ultrahigh and Broadband Photocurrent Responses in Graphene–Silicon Junctions. *ACS Nano* **2014**, *8* (10), 10270-10279, DOI: 10.1021/nn503484s.
- (2) Guo, X.; Wang, W.; Nan, H.; Yu, Y.; Jiang, J.; Zhao, W.; Li, J.; Zafar, Z.; Xiang, N.; Ni, Z.; Hu, W.; You, Y.; Ni, Z. High-performance graphene photodetector using interfacial gating. *Optica* **2016**, *3* (10), 1066-1070, DOI: 10.1364/OPTICA.3.001066.
- (3) Chen, Z.; Cheng, Z.; Wang, J.; Wan, X.; Shu, C.; Tsang, H. K.; Ho, H. P.; Xu, J.-B. High Responsivity, Broadband, and Fast Graphene/Silicon Photodetector in Photoconductor Mode. *Advanced Optical Materials* **2015**, *3* (9), 1207-1214, DOI: 10.1002/adom.201500127.
- (4) Selvi, H.; Hill, E. W.; Parkinson, P.; Echtermeyer, T. J. Graphene–silicon-on-insulator (GSOI) Schottky diode photodetectors. *Nanoscale* **2018**, *10* (40), 18926-18935, DOI: 10.1039/C8NR05285A.
- (5) Shen, J.; Liu, X.; Song, X.; Li, X.; Wang, J.; Zhou, Q.; Luo, S.; Feng, W.; Wei, X.; Lu, S.; Feng, S.; Du, C.; Wang, Y.; Shi, H.; Wei, D. High-performance Schottky heterojunction photodetector with directly grown graphene nanowalls as electrodes. *Nanoscale* **2017**, *9* (18), 6020-6025, DOI: 10.1039/C7NR00573C.