Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supporting Information

for

Enhancement of efficiency and long-term stability in graphene/Si-quantum-dot heterojunction photodetectors by employing bis(trifluoromethanesulfonyl)-amide as a dopant for graphene

Dong Hee Shin,* Chan Wook Jang,* Ju Hwan Kim,* Jong Min Kim, Ha Seung Lee, Sang Woo Seo, Sung Kim, and Suk-Ho Choi†

Department of Applied Physics and Institute of Natural Sciences, Kyung Hee University, Yongin 17104, Korea

*These authors contributed equally to this work.
† To whom correspondence should be addressed.
E-mail: sukho@khu.ac.kr

Table S1. Performance comparison of the TFSA-doped graphene/SQD:SiO_2/n-Si PDs with other graphene-based Si PDs previously-reported in literatures.

Device Structure	R [AW^{-1}]	EQE (%)	D* (cm $Hz^{1/2}$ W^{-1})	NEP [pW $Hz^{-1/2}$]	LDR [dB]	Ref
TPA-doped tri-layer graphene/Si	0.435 @ 488 nm	65 @ 550-800 nm	2.1×10^{8}	33		7
Graphene/thin SiO_2/Si	0.73 @ 890 nm	60 @ 650 nm	4.2×10^{12}	0.075	90	24
Graphene/Si	0.29 @ 850 nm		3.9×10^{11}			25
Graphene/porous Si	0.35 @ 950 nm	60 @ 500 nm				26
Nanographene/Si	0.1~0.3 @ white LED					27
RGO/Si	0.064 @ 445 nm		1.18×10^{12}			28
Si QDs/graphene/Si	0.495 @ 877 nm	80 @ 500 nm	7.4×10^{9}	6.7		29
B-doped Si QDs/graphene/Si	~ 10^{9} @ 532 nm	~ 10^{12}@ 532 nm	~ 10^{13}			33
$AuCl_3$-doped graphene/Si QDs	0.35 @ 600 nm	72 @ 600 nm	8.9×10^{8}	560	73	11
TFSA-doped Graphene/Si QDs	0.413 @630 nm	84 @ 600 nm	1.1×10^{10}	45.73	92	This work

Figures for Supporting Information

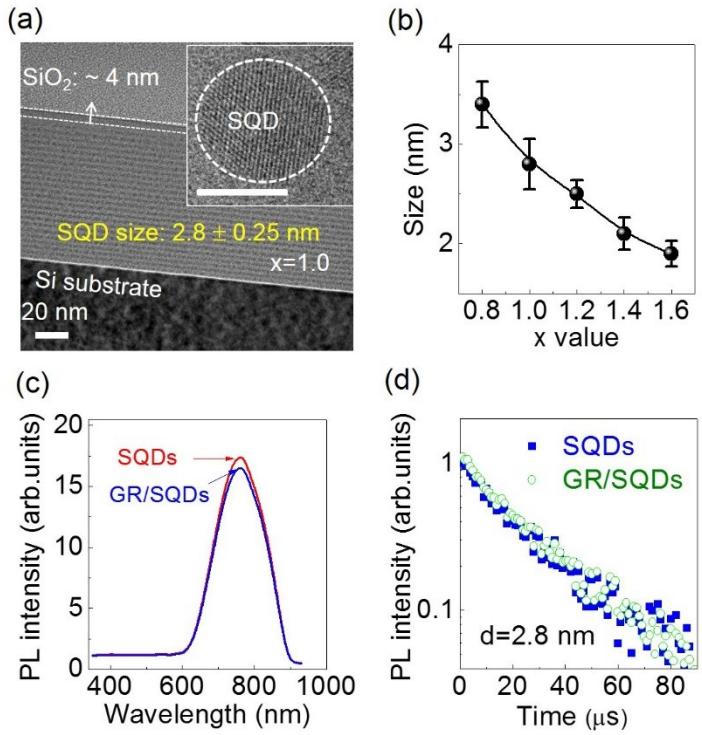

Figure S1. (a) Cross-sectional high-resolution transmission electron microscopy (TEM) image of 50-period 2 nm $SiO_{1.0}$/2 nm SiO_2 MLs after annealing at 1100 ^oC. The inset shows a magnified TEM image of a single SQD. The scale bar in the inset is 2 nm. (b) Average SQD size as a function of x value (c) PL spectra of SQDs:SiO_2 MLs and graphene/ SQDs:SiO_2 MLs on n-Si wafer. (d) PL decay curves of SQDs:SiO_2 MLs and graphene/ SQDs:SiO_2 MLs on n-Si wafer. Here, GR indicates graphene.

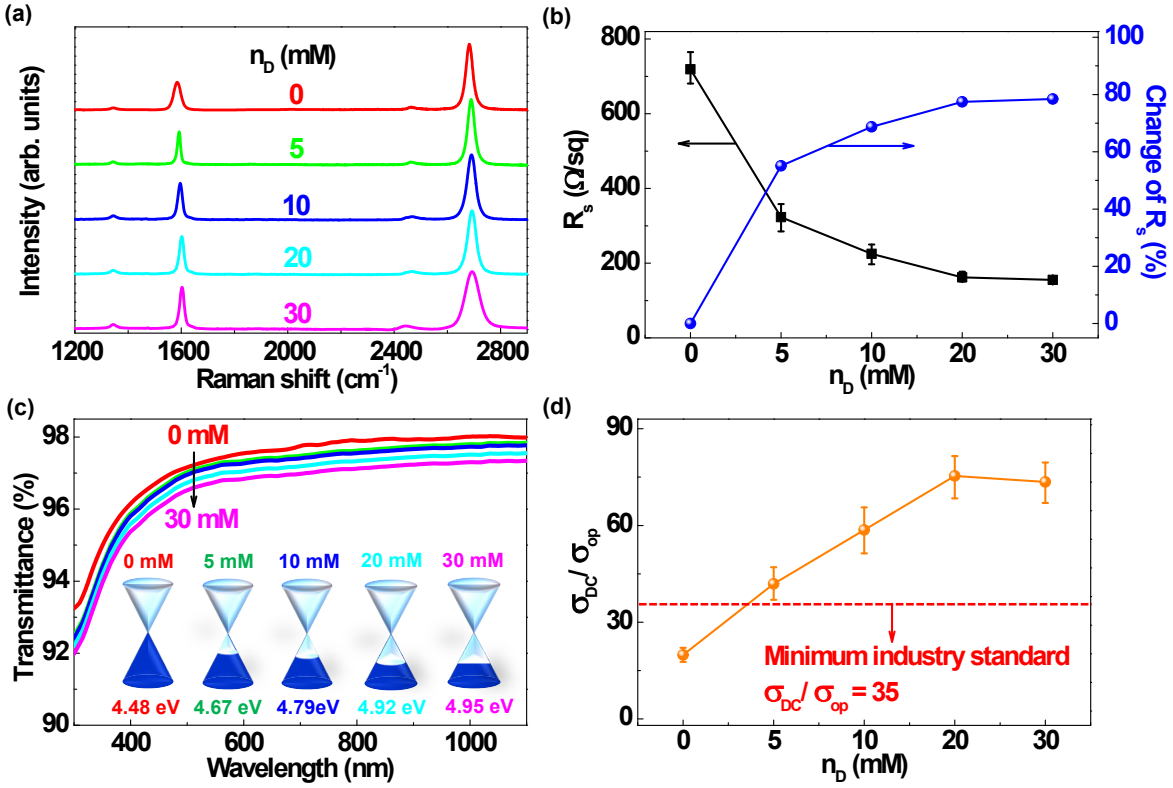

Figure S2. (a) Raman spectra of doped graphene layers for various n_D. (b) Absolute R_s its percentage change as functions of n_D. (c) Spectral transmittance spectra of doped graphene layers for various n_D. The inset shows work function of doped graphene layers as a function of n_D. (d) Calculated σ_{DC}/σ_{OP} of doped graphene layers as a function of n_D.

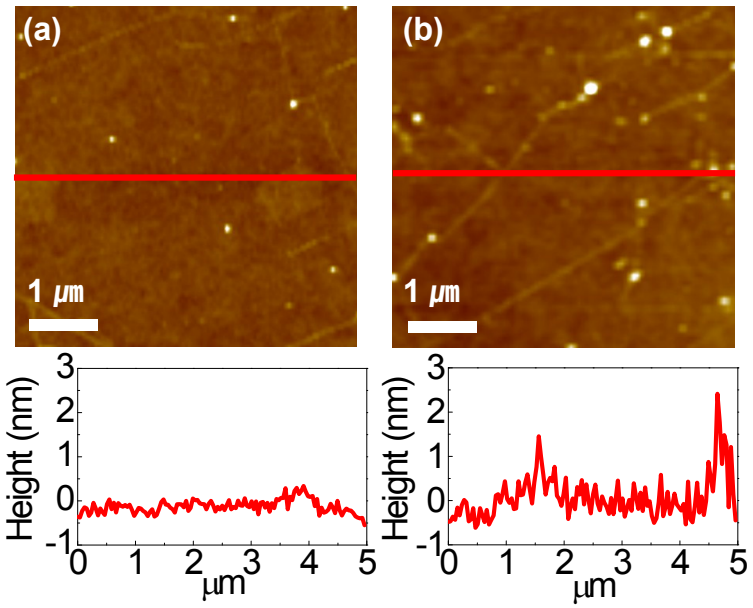

Figure S3. AFM images and height profiles of graphene sheets (a) before and (b) after doping at n_D = 20 mM. The scale bars indicate 1 μm.

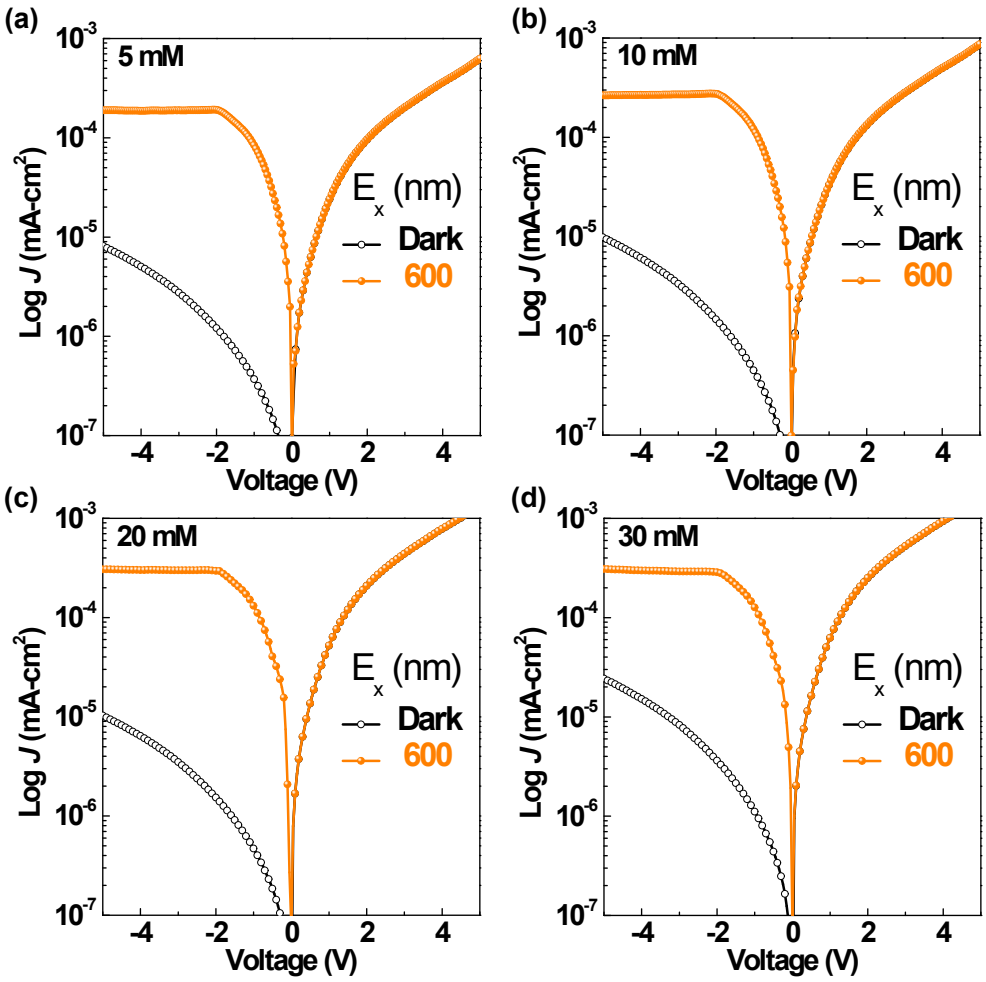

Figure S4. *J-V* curves under dark and illumination at λ = 600 nm for various n_D.

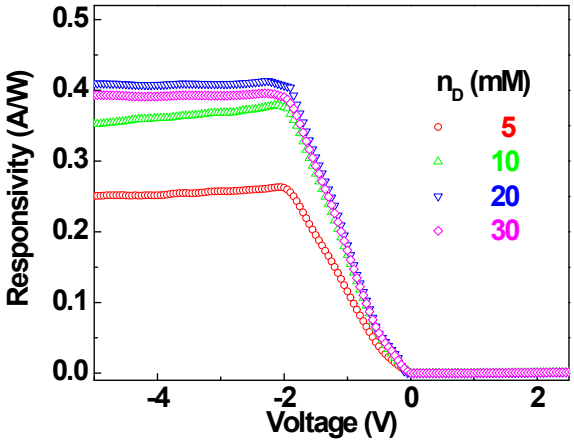

Figure S5. Responsivities as functions of bias at λ = 600 nm for various n_D.

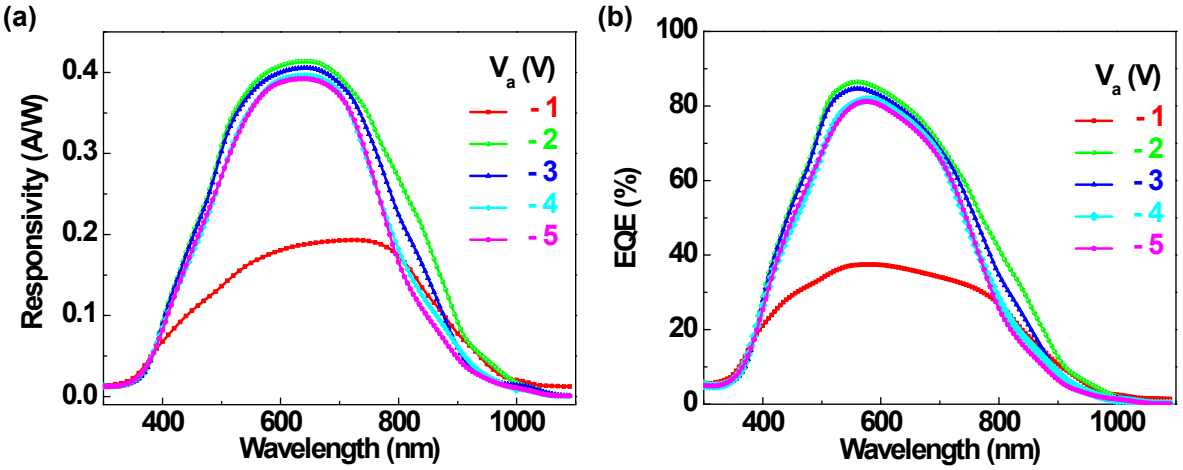

Figure S6. (a) Spectral responsivities and (b) quantum efficiencies under bias voltages from -1 to -5 V for n_D = 20 mM.

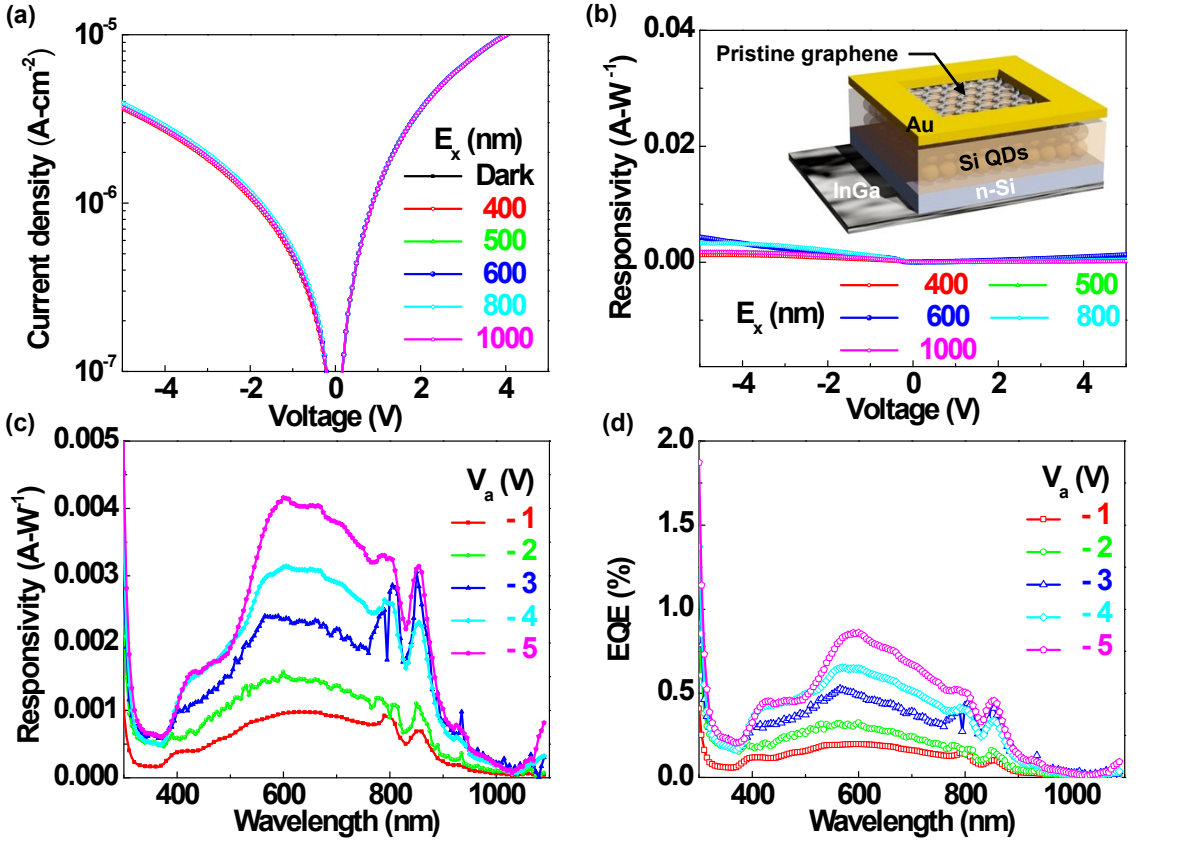

Figure S7. *J-V* curves under dark and illumination of a bare graphene/SQDs:SiO_2/n-Si PD. The illumination was done at λ from 400 to 1000 nm. (b) Responsivities as functions of bias at λ from 400 to 1000 nm. (c) Spectral responsivities and (d) external quantum efficiencies under bias voltages from −1 to −5 V.

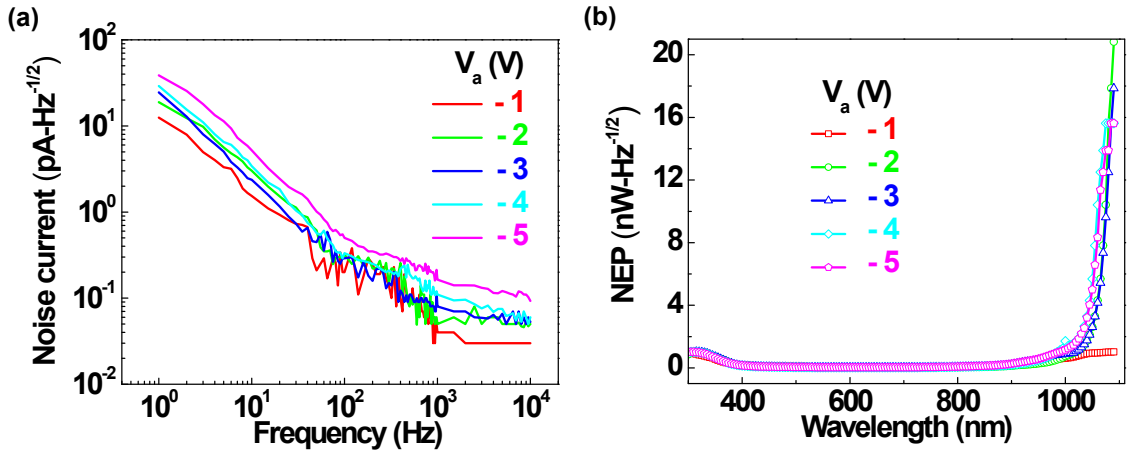

Figure S8. (a) Frequency-dependent noise current and (b) λ -dependent NEP under various bias voltages at n_D = 20 mM.

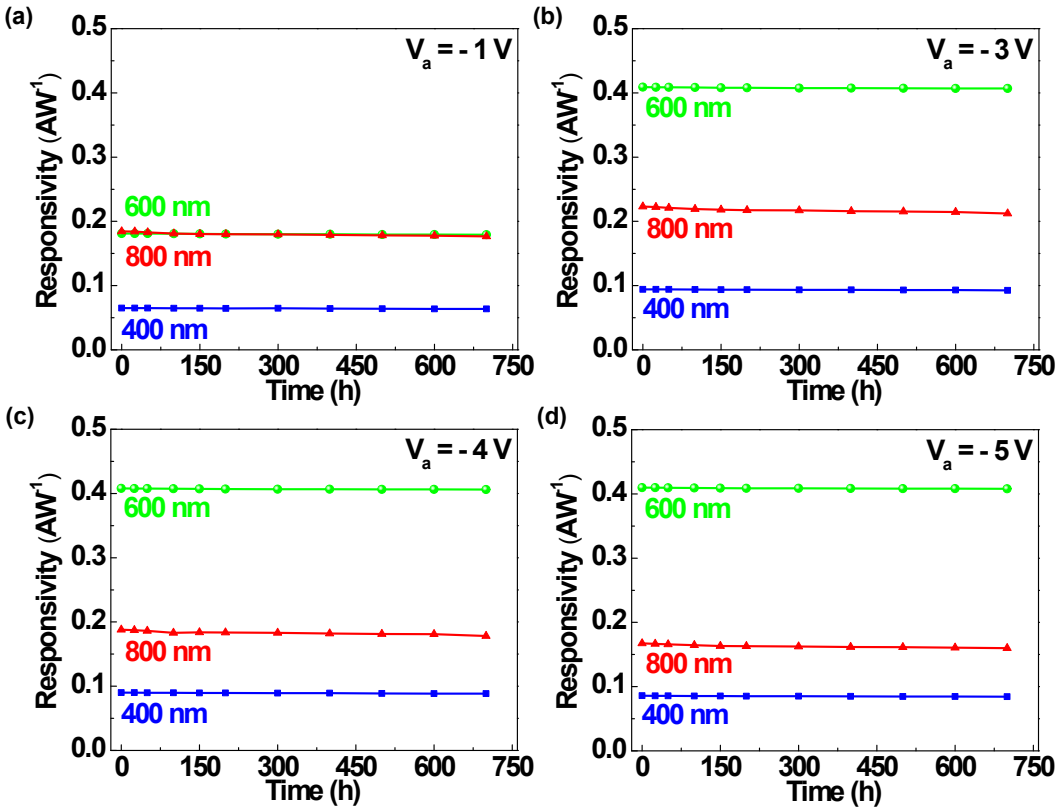

Figure S9. (a) Time-dependent responsivities at λ = 400, 600, and 800 nm under various V_a of (a) -1, (b) -3, (c) -4, and (d) -5 V, respectively.