Supporting information for

**Distinguishing Wavelength Using Two Horizontally Stacking Graphene/Thin Si/Graphene Heterojunctions**

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**Figure**

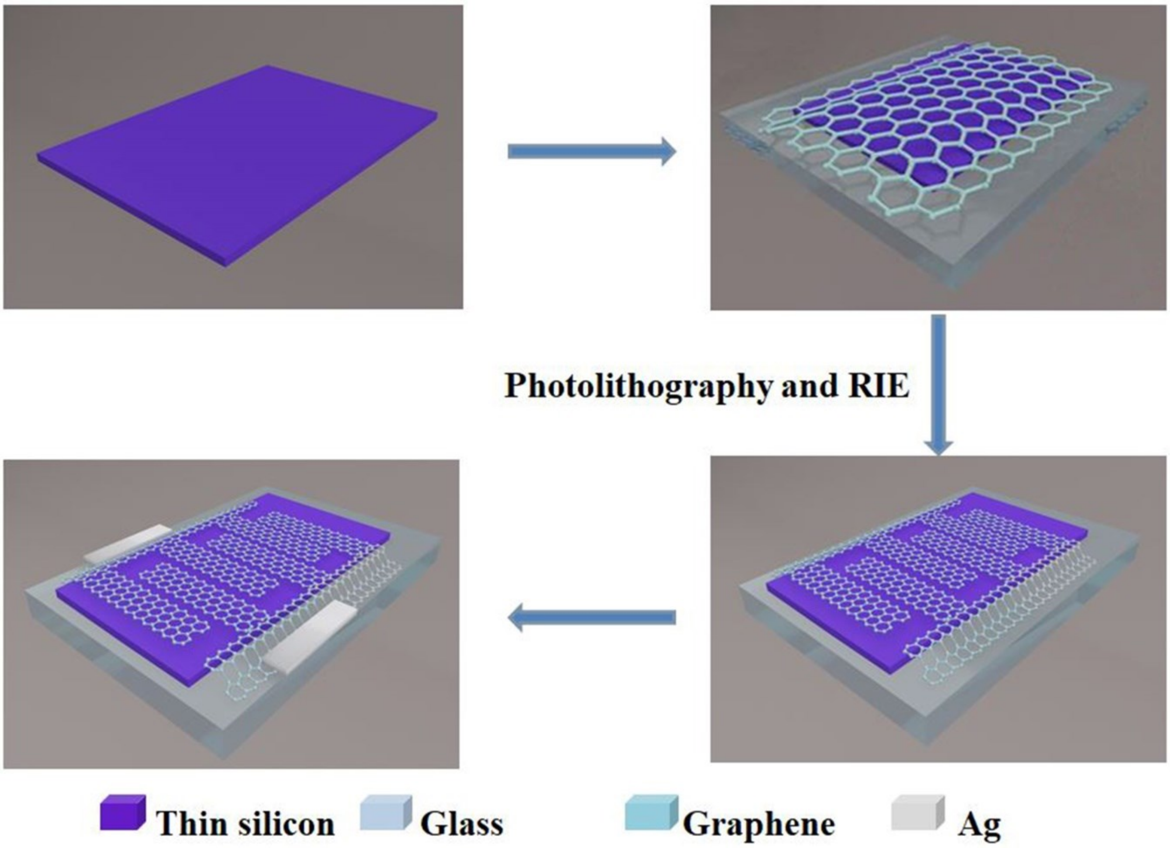


**Figure S1.** The flow chart of single graphene/thin Si heterojunction photodetector.

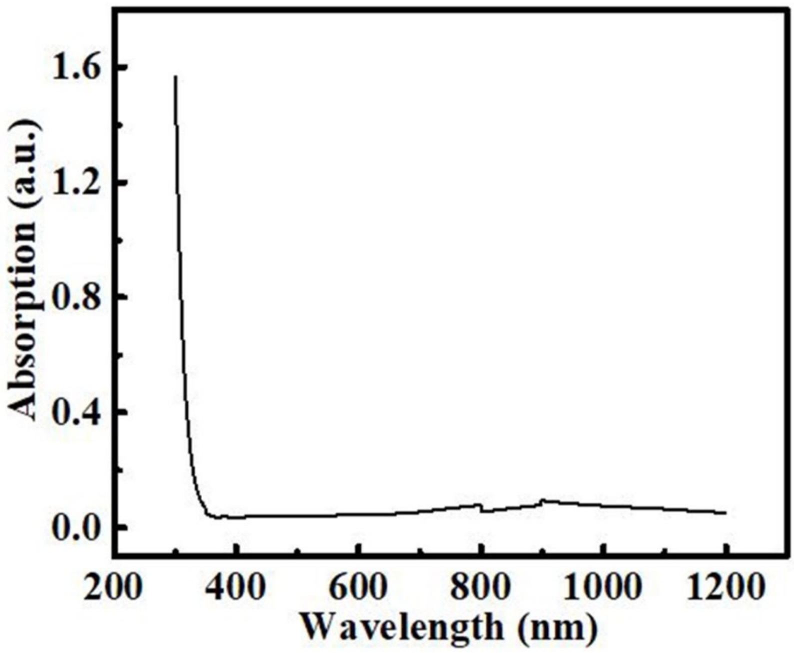


**Figure S2.** The absorption of glass.

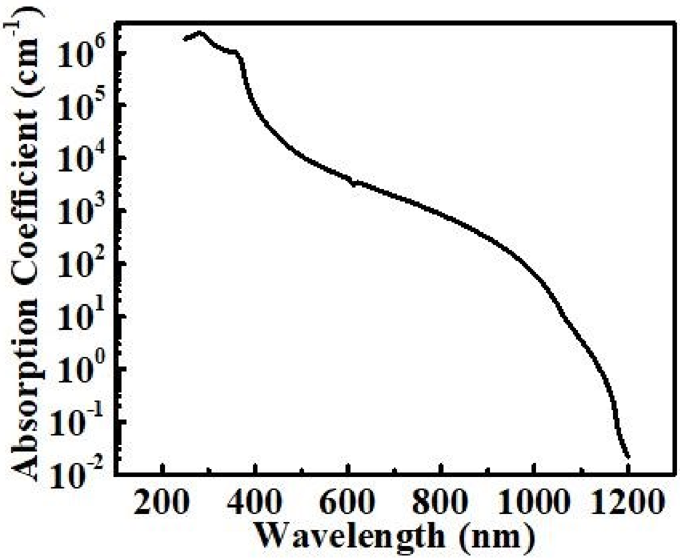


**Figure S3.** Absorption coefficient as a function of wavelength.

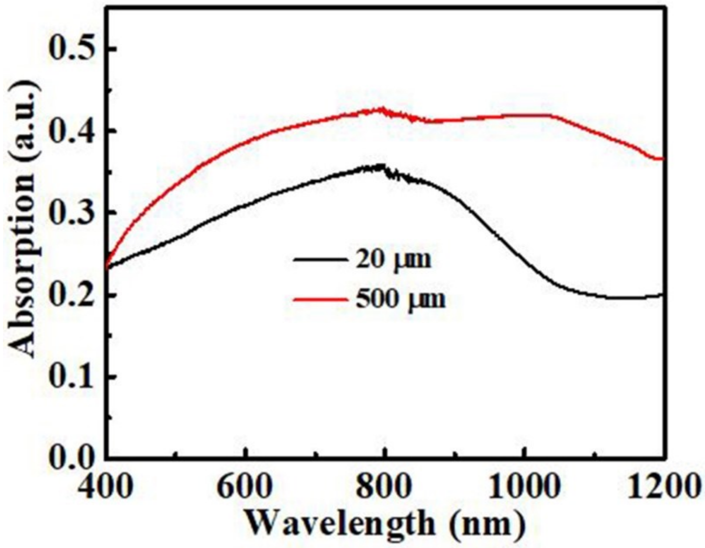


**Figure S4.** Light absorption spectra of thin Si substrates with varied thickness of 20 and 500 μm.

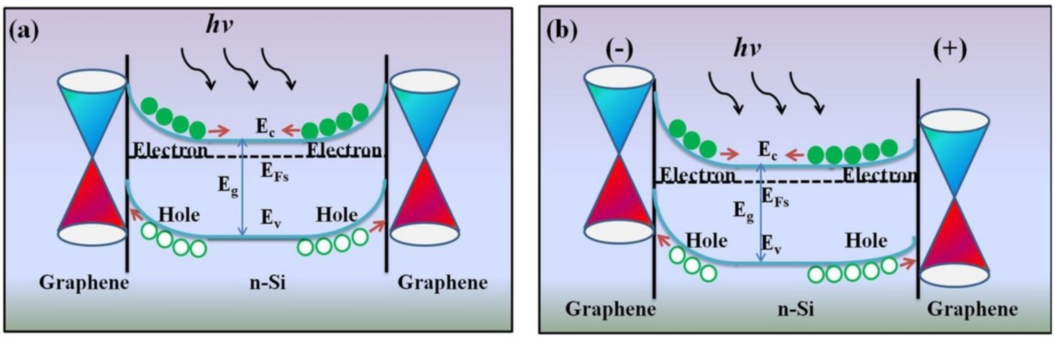


**Figure S5.** (a) Energy band diagram of the Gr/thin Si/Gr heterojunction photodetector at at a bias voltage of 0 V. (b) Energy band diagram of the Gr/thin Si/Gr heterojunction photodetector at forward bias voltage.

**Table S1.** Typical photodetection performances of Gr/Si heterostructure based devices.

| Devices | *R*[A W$^{-1}$] | *D**[Jones] | *EQE*[%] | Wavelength[nm] | Ref |
|---|---|---|---|---|---|
| Graphene/$WS_2$/*n*-Si | 54.5 | 4.1 × $10^{12}$ | - | 800 | [1] |
| Graphene/Si | 52 | - | - | 780 | [2] |
| Graphene/*n*-Si with interdigital $SiO_2$ | 0.635 | - | 98 | 850 | [3] |
| Graphene/Si | 0.73 | 5.77 × $10^{13}$ | - | 890 | [4] |
| Graphene/ Thin Si | 0.0505 | 1.49 × $10^{12}$ | 7.72 | 810 | This Work |

## Calculation of hole diffusion length:

$$L_p = \sqrt{D_p * \tau_p} \tag{1}$$

$$D_p = \frac{K * T}{q} * \mu_p \tag{2}$$

Where $\mu_p$ is hole mobility, $\tau_p$ is carrier life time. The experimental result is 316 μm ($KT/q$=1/40, $\mu_p$=500 $cm^2\ V^{-1}\ s^{-1}$), $\tau_p$=200 μs).

**Calculation of responsivity, specific detectivity, and EQE:**

To quantitatively assess the photoresponse of the color photodetector, both responsivity ($R$) and specific detectivity ($D$*) are calculated. The responsivity which is defined as the photocurrent generated per unit power of the incident light on the effective area of a photodetector can be estimated using the following equation:[5]

$$R = \frac{I_\lambda - I_d}{P_\lambda S} \tag{3}$$

Where $I_\lambda$ is the photocurrent, $P_\lambda$ is the light intensity, $I_d$ is the dark current, $S$ is the effective illuminated area ($S$ = 0.48 $cm^2$). By using the above equation, and many experimental values ($I_\lambda$= 1.23×$10^{-8}$ A, $I_d$ = 1.72×$10^{-9}$ A, $P$ = 5.00×$10^{-4}$ W $cm^{-2}$), the $R$ at a bias voltage of 2 V was estimated to be 50.46 mA $W^{-1}$.

In addition, the $D*$ represents the capability of a photodetector to probe the weakest optical signal, and can be expressed as:[6]

$$D^* = \frac{R\sqrt{S}}{\sqrt{2eI_d}} \tag{4}$$

Where $R$ is the responsivity, $S$ is the effective area of the photodetctor, $e$ is the electronic charge, and $I_d$ is the dark current. Based on the above equation as well as many constants derived from experiment($R$ = 50.46 mA $W^{-1}$, $I_d$ = 1.72×$10^{-9}$ A, $e$ = 1.602×$10^{-19}$ C), the $D*$ at a bias voltage of 2 V is calculated to be 1.49×$10^{12}$ Jones.

As a matter of fact, similar evolution is also observed on external quantum efficiency ($EQE$), which is defined as the number of electrons probed per incident photon and can be estimated by the equation:

$$EQE = \frac{hcR_\lambda}{e\lambda} \quad (5)$$

where *h* is the Planck's constant, *c* is the velocity of light, *e* is the electronic charge, and λ is the exciting wavelength, respectively. The *EQE* at a light intensity of 500 μW $cm^{-2}$ is 7.72%.

**The equations for different light intensities:**

$$y = 0.000020 \times e^{\frac{\lambda}{106.66}} + 0.0090 \qquad p = 500\ \mu W\ cm^{-2} \quad (6)$$

$$y = 0.000016 \times e^{\frac{\lambda}{104.52}} + 0.0094 \qquad p = 800\ \mu W\ cm^{-2} \quad (7)$$

$$y = 0.000040 \times e^{\frac{\lambda}{115.39}} + 0.0076 \qquad p = 1000\ \mu W\ cm^{-2} \quad (8)$$

$$y = 0.000059 \times e^{\frac{\lambda}{120.91}} - 0.0068 \qquad p = 1200\ \mu W\ cm^{-2} \quad (9)$$


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