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Electronic Supplementary Information for

Tunable positive and negative photoconductive photodetector based on a gold/graphene/p-type silicon heterojunction

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1. The source-drain current of transferred graphene versus gate bias was measured using the circuit shown in Fig. S1a. The source-drain bias was 5 mV. Fig. S1b indicates that the minimum graphene current was obtained at a gate voltage of about 35 V, suggesting that graphene was p-type doped, which originated from the dopants introduced during the transfer process.

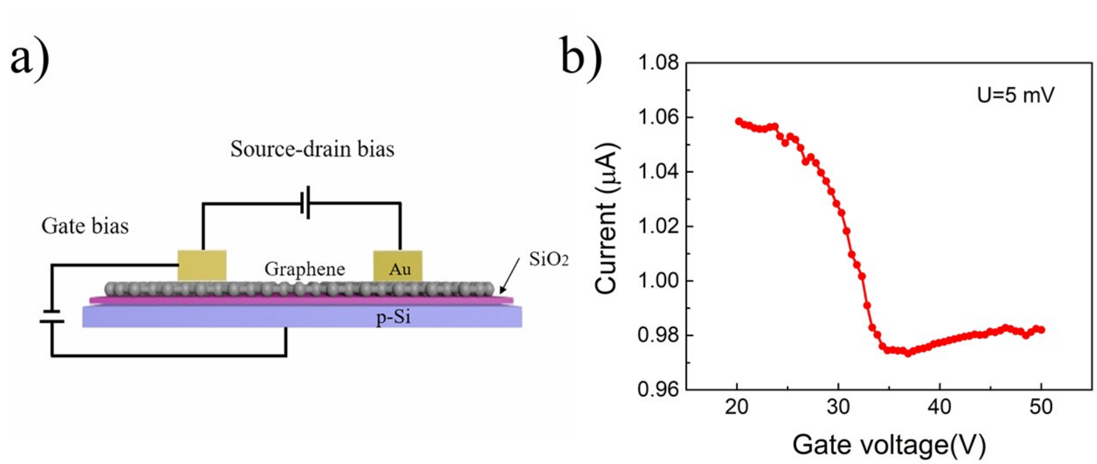

Figure S1 (a) Schematic of the measured circuit. (b) Current of graphene versus gate voltage at a source–drain bias U of 5 mV.

2. Au interdigitated fingers were deposited on a p-Si substrate by the same procedure to fabricate a reference Au/p-Si device, as shown in Fig. S2a. The absorption spectrum of the p-Si substrate is shown in Fig. S2b. Fig. S2c reveals that the current of the p-Si substrate increased with voltage until it reached saturation at about 0.7 V. Positive photocurrent was generated but it was smaller than the photocurrent of the Au/graphene/p-Si device under the same conditions. At high power density, even at 3580 mW cm^{-2} (power ~450 mW), no negative photocurrent was observed from the reference device (Fig. S2d).

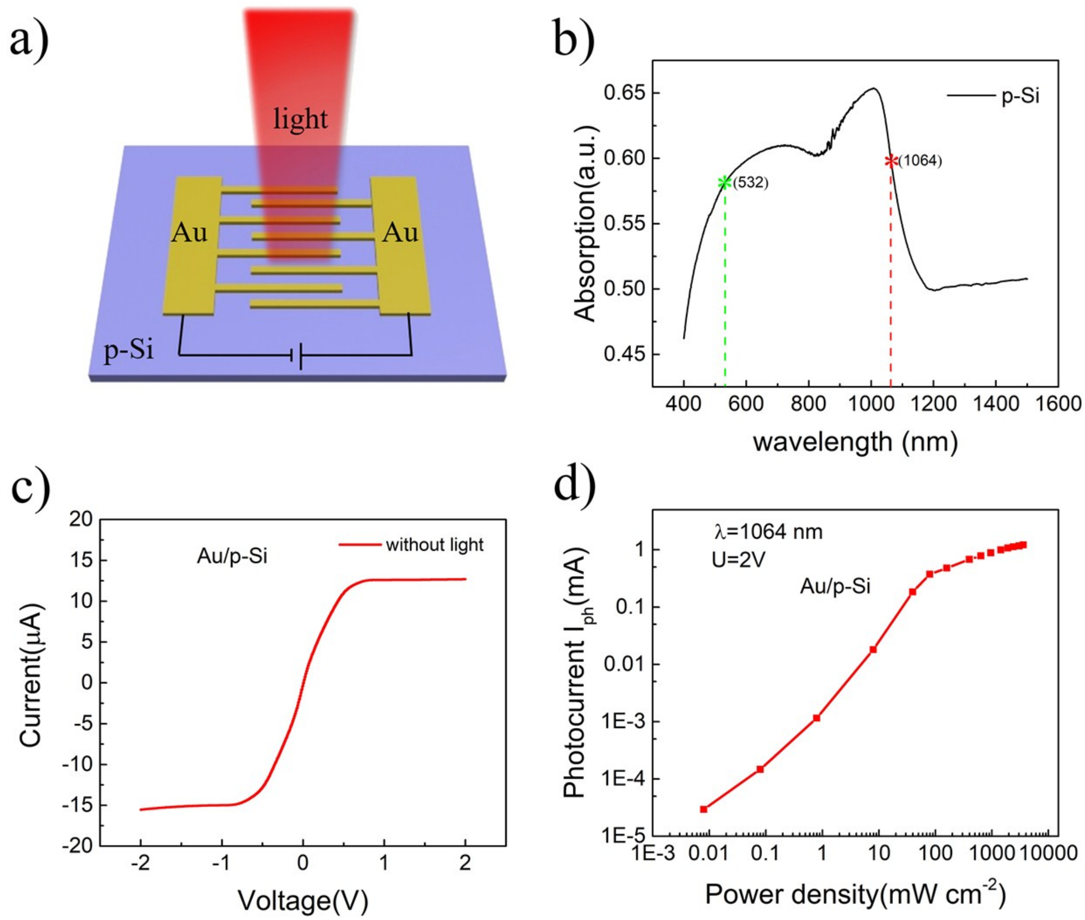

Figure S2 (a) Schematic of the reference Au/p-Si device. (b) Absorption spectrum of the p-Si substrate. (c) Current versus voltage curve (from −2 to 2 V). (d) Photocurrent versus power density under 1064-nm illumination at 2 V.

3. The same Au/graphene/p-Si device was measured under 532-nm laser irradiation. At low power density, the photocurrent was positive and increased with power, as shown in Fig. S3a. The maximum positive photocurrent was generated at 113 mW cm^{-2} and then photocurrent gradually decreased with power until it changed to a negative value at 1131 mW cm^{-2}. Fig. S3b reveals that the dependence of photocurrent under 532-nm irradiation on source–drain bias was

similar to that under 1064-nm laser irradiation. Photocurrent displayed a nonlinear relationship with source–drain bias because of the heterojunction formed between graphene and p-Si.

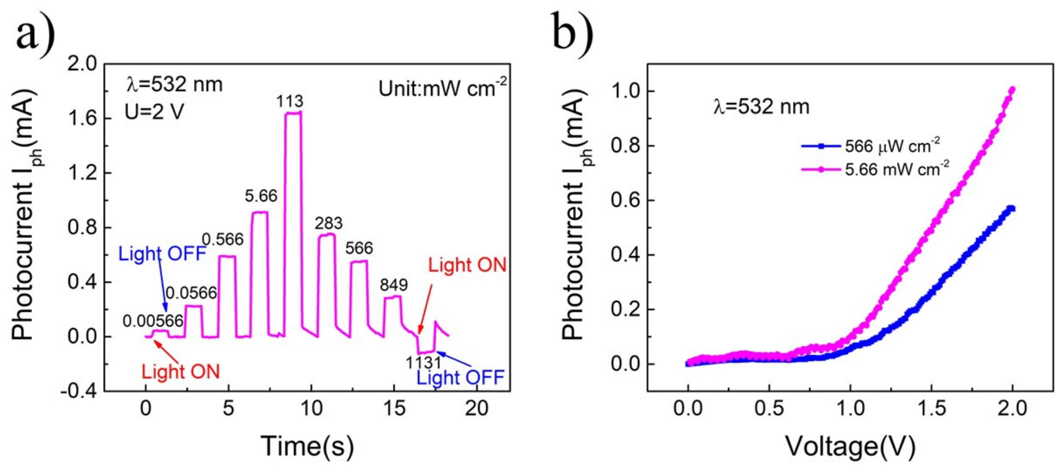

Figure S3 (a) Photocurrent response versus time at low and high power density and a bias of 2 V. (b) Photocurrent versus source–drain bias. The light source was a 532-nm laser.

4. The built model matched well the observed experimental data as shown in Fig. S4. The fitting value of δ was 0.989, which was consistent with the consideration ($\delta < 1$). The small deviations of experiment data with fitting curve may originate from the factors which could have an influence on the photocurrent but have not been considered into the model, such as gold electrodes and p-Si substrate.

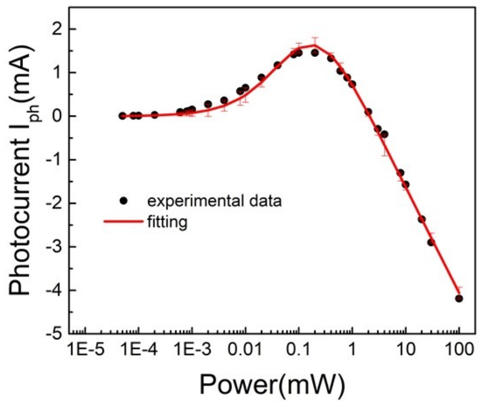

Figure S4 Fitting results of photocurrent as a function with laser power. The source-drain bias was 2 V. The laser source was 1064-nm laser.

5. The Au/graphene/p-Si device was operated under a vacuum of 10^{-4} Pa, as shown in Fig. S5. At low power density, the photocurrent was negative. Heat induced by light could not be dissipated under the vacuum conductions, so the phonon–carrier scattering effect caused by local heat was more obvious than that without vacuum.

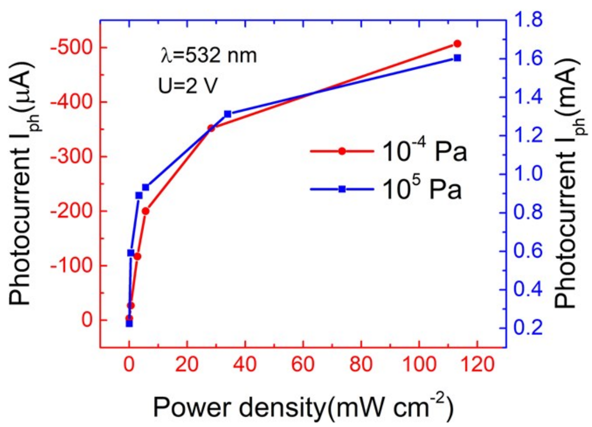

Figure S5 Photocurrent versus power density at 2 V under 532-nm illumination in air or under vacuum conditions.

6. Under the irradiation of 1064-nm laser, we also observed the conversion of positive and negative photocurrent with the increase of power when copper interdigitated electrodes were used in the device.

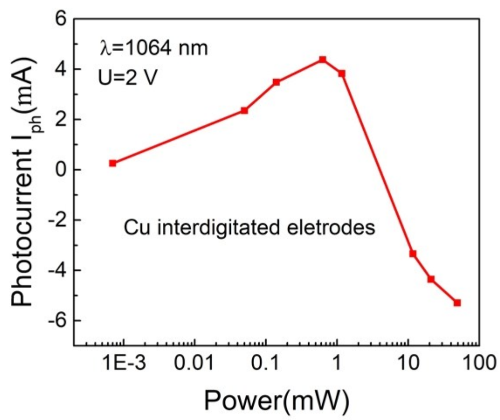

Figure S6. Device photocurrent versus power density under 1064-nm laser irradiation at a source–drain bias of 2 V. The interdigitated electrodes are copper nanofilms.