Electronic Supplementary Material (ESI) for Nanoscale.


# Supplementary Information for

## Ultra-broadband and high response of the $Bi_2Te_3$-Si heterojunction and its application on photodetector at room temperature in harshworking environments

Jiandong Yao, Jianmei Shao, Yingxin Wang, Ziran Zhao, Guowei Yang

## S1. Components of the PLD-grown $Bi_2Te_3$ thin film

The energy dispersive spectrum (EDS) analysis of the PLD-grown $Bi_2Te_3$ thin film is shown in Fig. S1. Components of the film are slightly deviated from the ideal stoichiometric ratio, with a little excess of Bi atoms. According to previous studies, excess Bi generates p-type carriers due to the formation of Bi (Te) anti-site defects.[1]

| Element | Weight% | Atomic% |
|---|---|---|
| Te L | 46.91 | 59.14 |
| Bi M | 53.09 | 40.86 |
| Totals | 100.00 | |

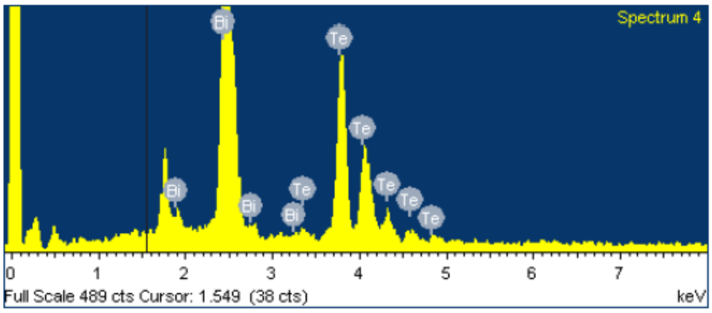


**Figure S1**. EDS analysis of the PLD-grown $Bi_2Te_3$ thin film.

**S2. Ohmic contacts between Ag (Pt) and Si ($Bi_2Te_3$)**

The current-voltage (I-V) characteristics of Ag/Si/Ag and Pt/$Bi_2Te_3$/Pt are shown in Fig. S2(a) and Fig. S2(b), respectively. The linearity of the lines reveals relatively good ohmic contact between Ag (Pt) and Si (TI).

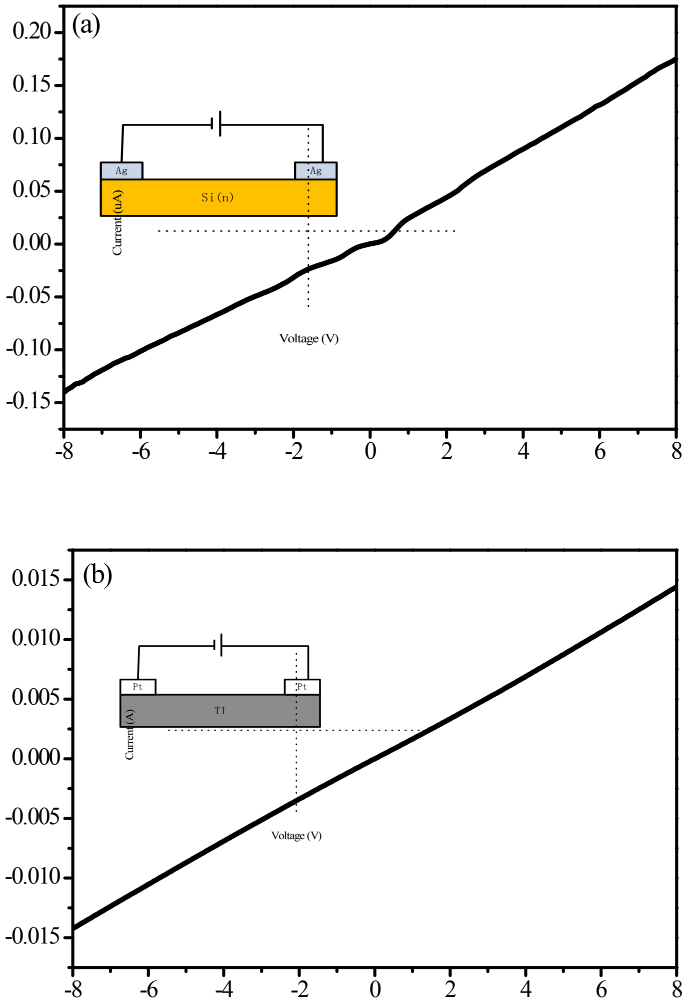


**Figure S2**. Ohmic contacts between Ag (Pt) and Si ($Bi_2Te_3$). (a) The I-V curve of Si with Ag electrodes. (b) The I-V curve of $Bi_2Te_3$ with Pt electrodes. The insets on the top left corner illustrate the structure of the devices.

**S3. Long-term switching behavior of the device**

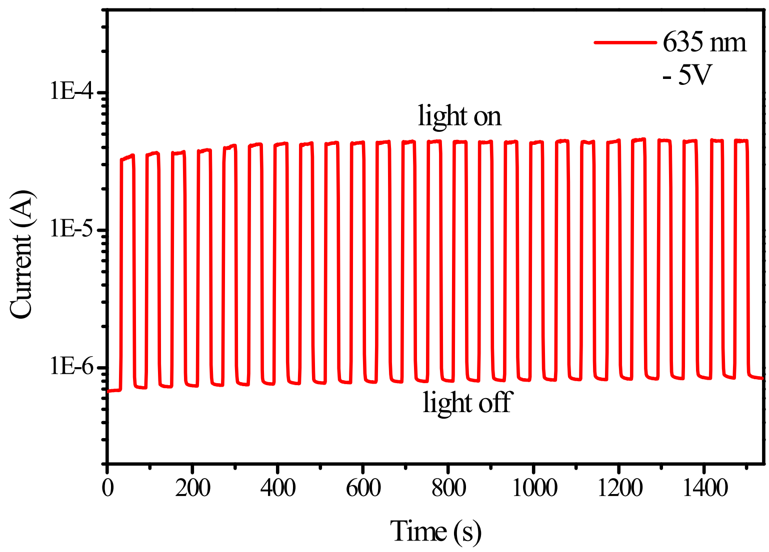


**Figure S3.** Time-dependent switching behavior for c.a. 1500 s. Source-drain bias: -5 V.

### S4. The response and recovery times of the device

We record the current during the fast mechanical chop of the illumination. No data point is recorded at the rising and falling edge. Therefore, the rising and falling times of the device must be less than c.a. 100 ms, the shortest sampling interval of our electrical measurement instrument.

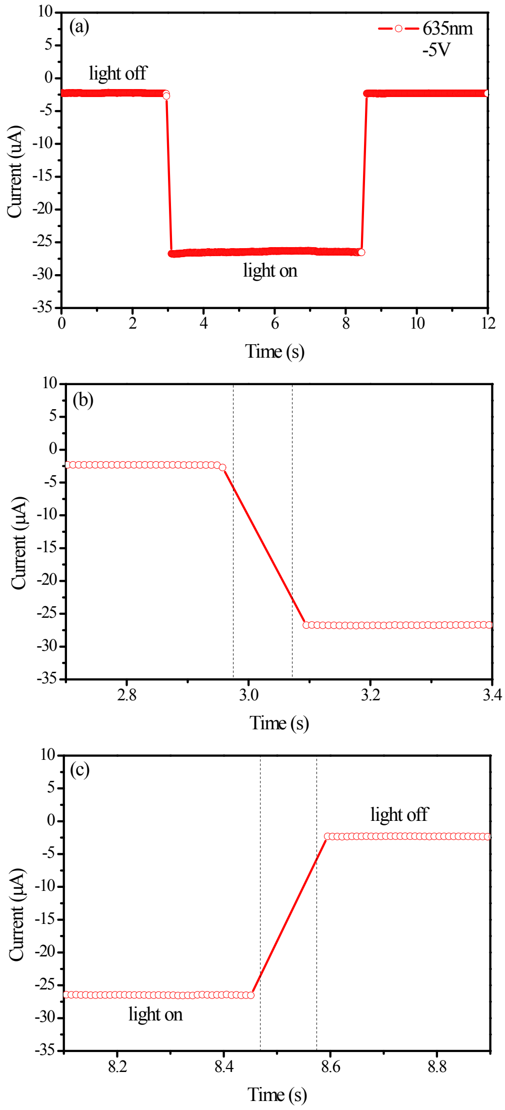


**Figure S4.** The rising and falling times of the photodetector. (a) An enlarged switching cycle. (b) Enlarged rising edge of (a). (c) Enlarged decay edge of (a). Note that the chopper (plastic sheet) can not completely block the incident light. Therefore, the base current becomes relatively large.

**S5. Calculation of photosensitivity (S) responsivity (R) and detectivity (D*).**

Photosensitivity (S), responsivity (R), and detectivity (D*) were calculated using the following equations. [2-4]

$$S = \frac{I_p - I_d}{I_d * P}$$

$$R(AW^{-1}) = \frac{I_p - I_d}{P_{opt}}$$

$$D^* = A^{1/2} R / (2qI_d)^{1/2}$$

where $I_p$, $I_d$ , P, $P_{opt}$ , A, q are photocurrent, dark current, incident light power density, incident light power, active area, the unit of elementary charge, respectively.

**Table S1.** Summary of the performances of G/GO based photodetector.

| Device Structure | Responsivity (A/W) | Response/Recovery time | Photosensitivity ($cm^2/mW$) | Response range | Detectivity ($cm*Hz^{1/2}*W^{-1}$) | Ref |
|---|---|---|---|---|---|---|
| $Bi_2Te_3/Si$ | 1 | <100ms/<100ms | $10^3$ | 370 nm ~ 118.8 μm | $4.7*10^{10}$ | Our work |
| GO junction | 0.0236 | 105ms/105ms | 0.024 | 290 nm ~ 1610 nm | $3.31*10^7$ | J. Mater. Chem. C[5] |
| G/Si | 0.435 | 1.2ms/3ms | 0.26 | 488 nm ~ 730 nm | $1.4*10^8$ | Nano Lett[6] |
| GO/SiNW | 0.009 | 26.5s/25.6s | 3.4 | 532 nm ~ 118.8 μm | ND | Small[7] |
| Pd/G/TI | 0.006 | ND | ND | 632 nm ~ 1550 nm | ND | Nature Photonics[8] |
| G | 4 | ND | ND | 532 nm ~ 3200 nm | ND | Nature Nano[9] |
| G | 8.6 | >100s/>100s | < 0.001 | 532 nm ~ 10 μm | ND | Nature Com[10] |
| G/QD | $10^7$ | 100 ms/200ms | ND | 500 nm ~ 1600 nm | $7*10^{13}$ | Nature Nano[11] |
| G-Bi2Te3 | 35 | 9.3 ms/ 17.7 ms | 0.03 | 300 nm ~1600 nm | ND | ACS Nano[12] |

**Table S2.** Summary of the performances of G/GO based self-power photodetectors.

| Device Structure | Responsivity (A/W) | Response/Recovery time | $I_{light}/(I_{dark}*P_{opt})$ ($mW^{-1}$) | Detectivity ($cm*Hz^{1/2}*W^{-1}$) | Ref |
|---|---|---|---|---|---|
| $Bi_2Te_3/Si$ | 0.017 | <100ms/<100ms | $7.5*10^5$ | $2.5*10^{11}$ | Our work |
| GO junction | $2*10^{-6}$ | 105ms/105ms | $2.2*10^4$ | ND | J. Mater. Chem. C[5] |
| G/Ge | 0.052 | 20us/108us | $2*10^3$ | $1.38*10^{10}$ | Appl. Mater. Interfaces[13] |
| G/GaAs | 0.002 | 72us/122us | $6.3*10^5$ | $1.83*10^{11}$ | Adv. Funct. Mater.[4] |
| G | 0.0005 | ND | ND | ND | Nature Nano[14] |

G: graphene, GO: graphene oxide, NW: nanowire, ND: no data, QD: quantum dots.

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