Supporting Information

Fast solution method to prepare hexagonal tellurium nanosheets for optoelectronic and ultrafast photonic applications

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Experimental

Preparation of Sodium Hydrogen Telluride (NaHTe)

NaHTe was synthesized through a simple redox reaction.[1, 2] Briefly, 0.34 g of $NaBH_4$ was dissolved in 6 mL of deionized water and then 0.51 g of Te powder was quickly added. Thereafter, the reaction vessel was sealed with a rubber stopper. Besides, a small pinhole was provided on the rubber stopper to ensure that H_2 generated by the reaction is discharged in time. During the reaction, the system was stirred and cooled in an ice-water bath to allow the reaction to proceed uniformly and slowly. After about 8 h, the black Te powder disappeared and a white sodium tetraborate precipitate was produced. The upper clear supernatant after stopping stirring for a while was the prepared NaHTe solution.

Z-Scan Characterization

The Z-scan characterization was performed using the methods reported previously.[3] The excitation lasers for the Z-scan experiments were delivered by a Ti: sapphire oscillator (800 nm, 95 ± 10 fs, 1 kHz, Spitfre Ace, Spectra-Physics). The laser power was controlled by an optical attenuator and then focused by a convex lens. Lenses with different focal lengths and waist radii were used at 1550 nm to achieve an obvious saturated absorption effect. The sample was moved along the optical axis by a computer-controlled motor. The incident laser beam was divided into two parts; the laser beam passing through the hexagonal Te nanosheets sample was detected by the power meter as the signal light and other beam was used as the reference light, which was directly captured by the power meter.

Fabrication of hexagonal Te nanosheets/PVP membrane

PVP (1 g) was added to hexagonal Te nanosheets/NMP slurry (10 mL) and then stirred for 60 min at 60 °C using a magnetic stirrer to prepared a Te/PVP colloid. After that, the colloid was slowly poured into a polytetrafluoroethylene (PTFE) mold, which was placed in a vacuum drying oven for 12 h at 80 °C to obtain the hexagonal Te nanosheets/PVP membrane.

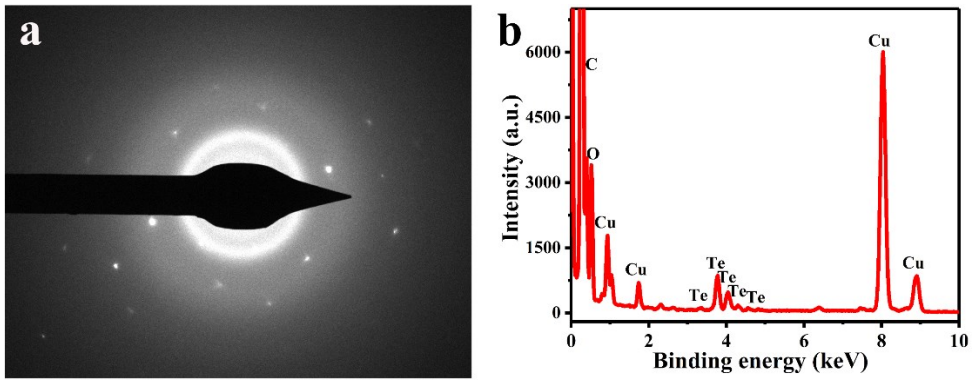


Fig. S1. (a) SAED pattern and (b) EDX spectrum of hexagonal Te nanosheet.

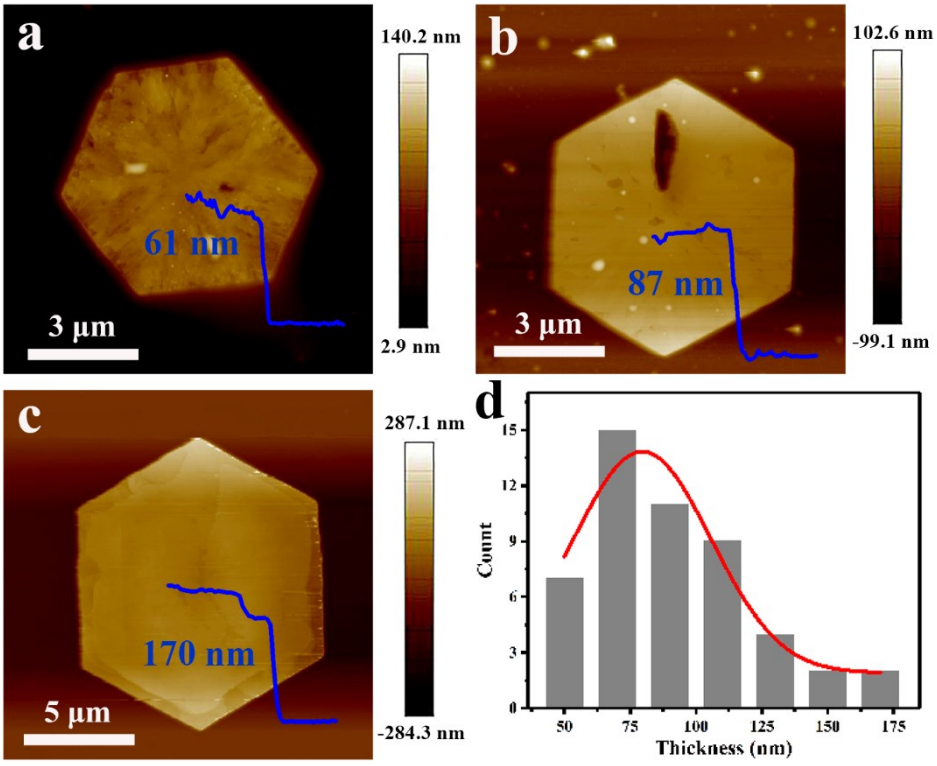


Fig. S2. AFM images of hexagonal Te nanosheets with thicknesses of (a) 61 nm, (b) 87 nm and (c) 170 nm; (d) Statistical distribution of the thickness of hexagonal Te nanosheets according to AFM.

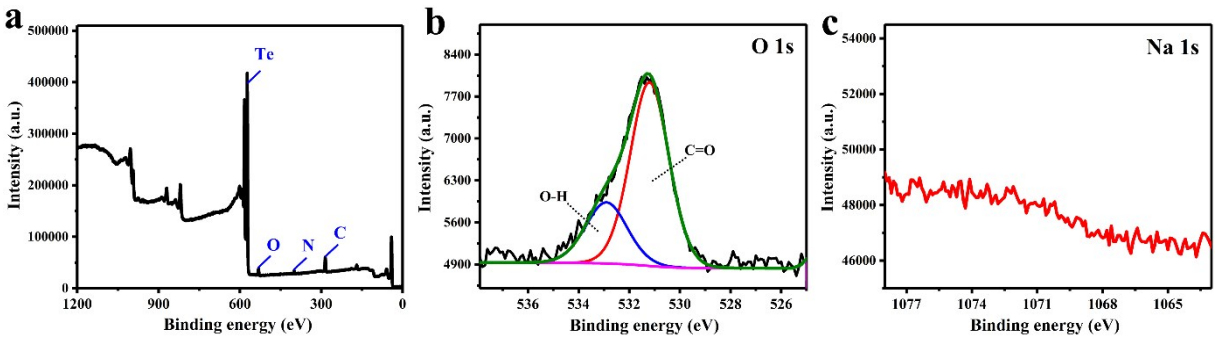


Fig. S3. XPS of hexagonal Te nanosheets. (a) survey spectrum, (b) O 1s and (c) Na 1s.

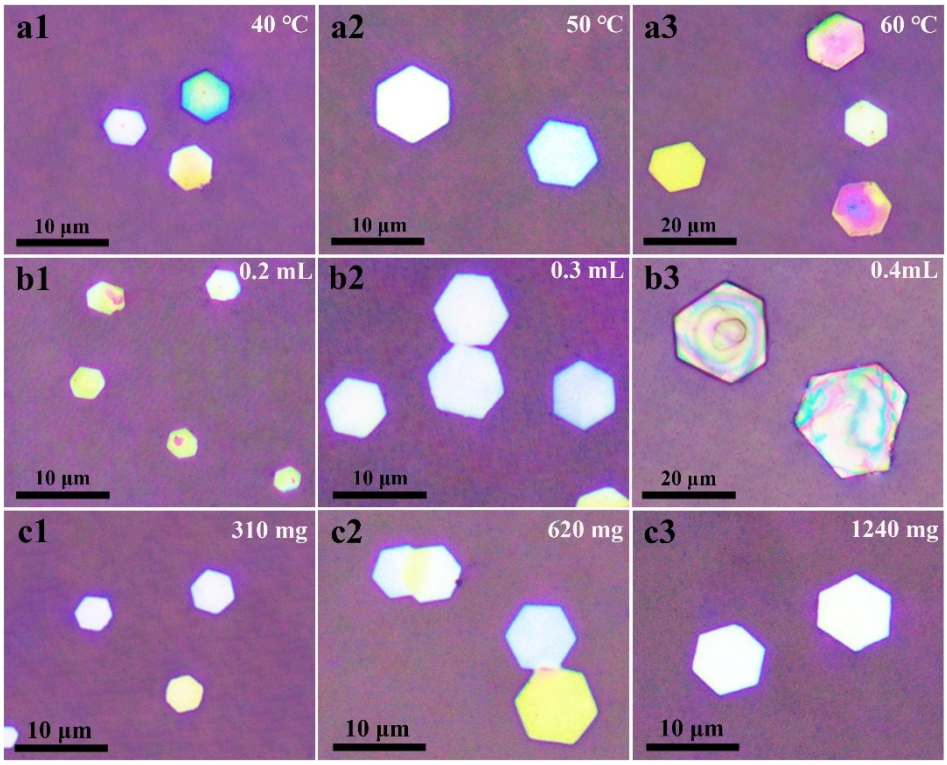


Fig. S4. OM images of hexagonal Te nanosheets with (a) different reaction temperature, 40 ℃, 50 ℃ and 60 ℃, (b) different amount of NaHTe, 0.2 mL, 0.3 mL and 0.4 mL, (c) different PVP content, 310 mg, 620 mg, and 1240 mg.

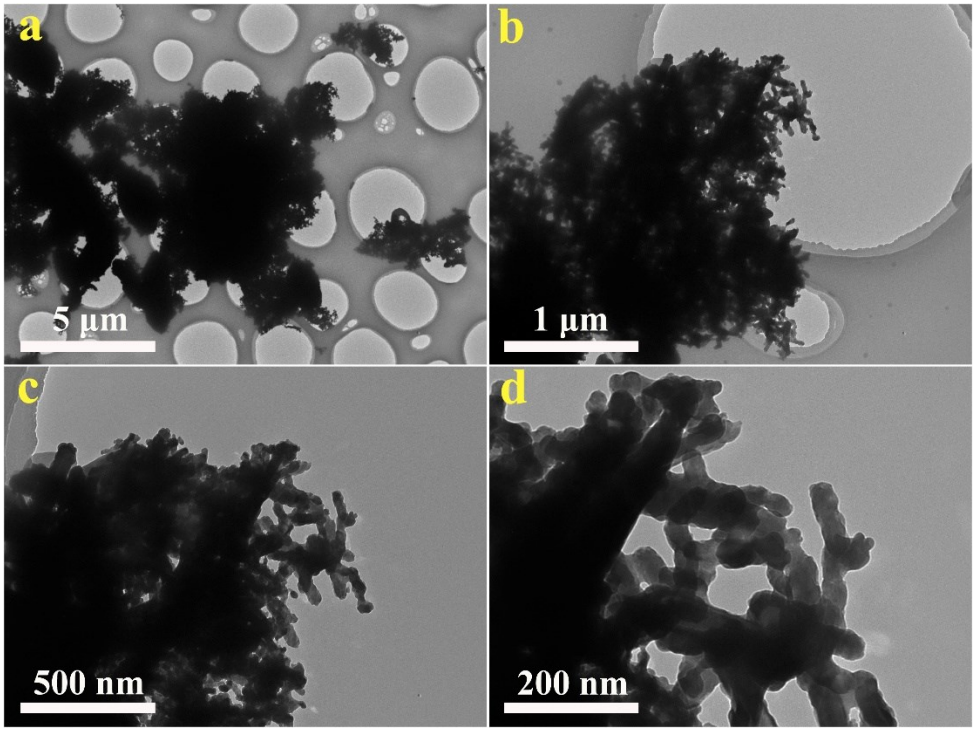


Fig. S5. TEM images of Te material prepared without PVP.

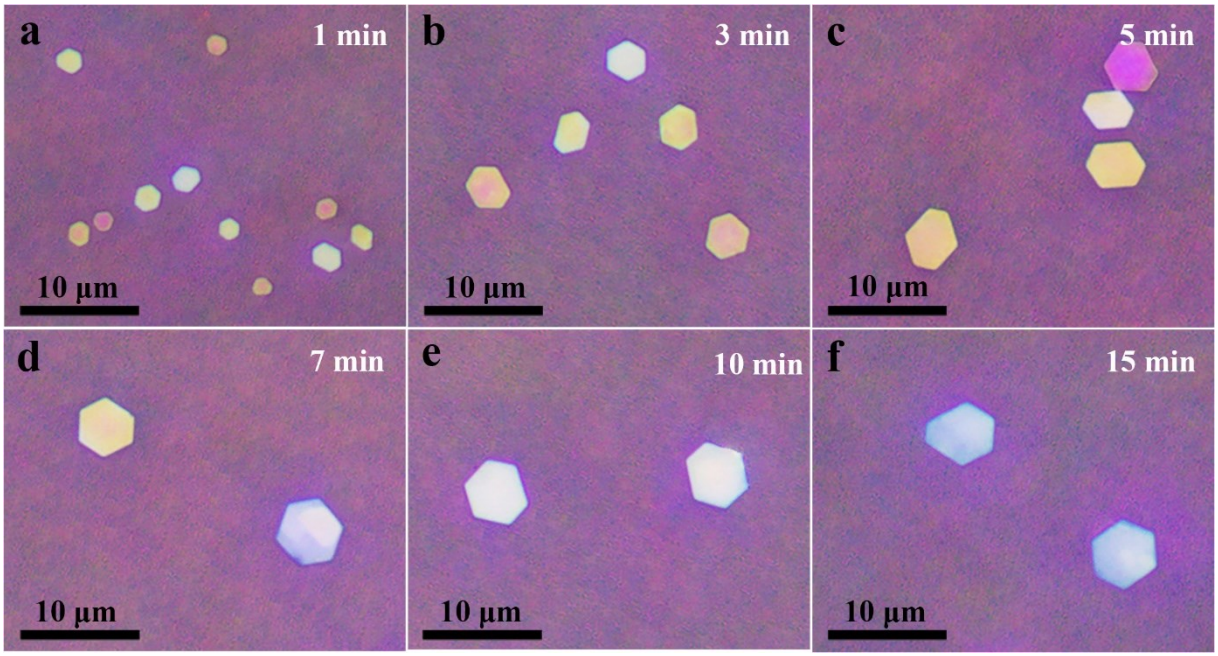


Fig. S6. OM images of hexagonal Te nanosheets with different reaction time (a) 1 min, (b) 3 min, (c) 5 min, (d) 7 min, (e) 10 min and (f) 15 min.

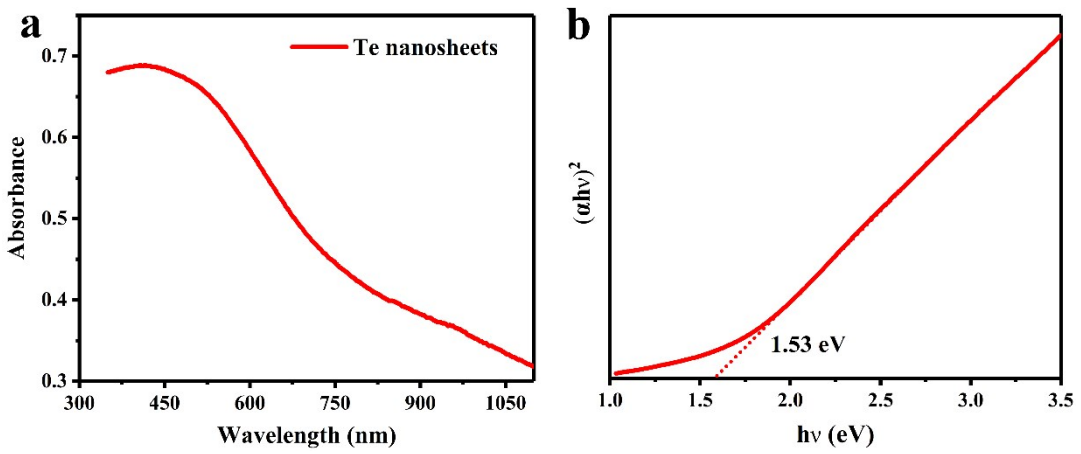
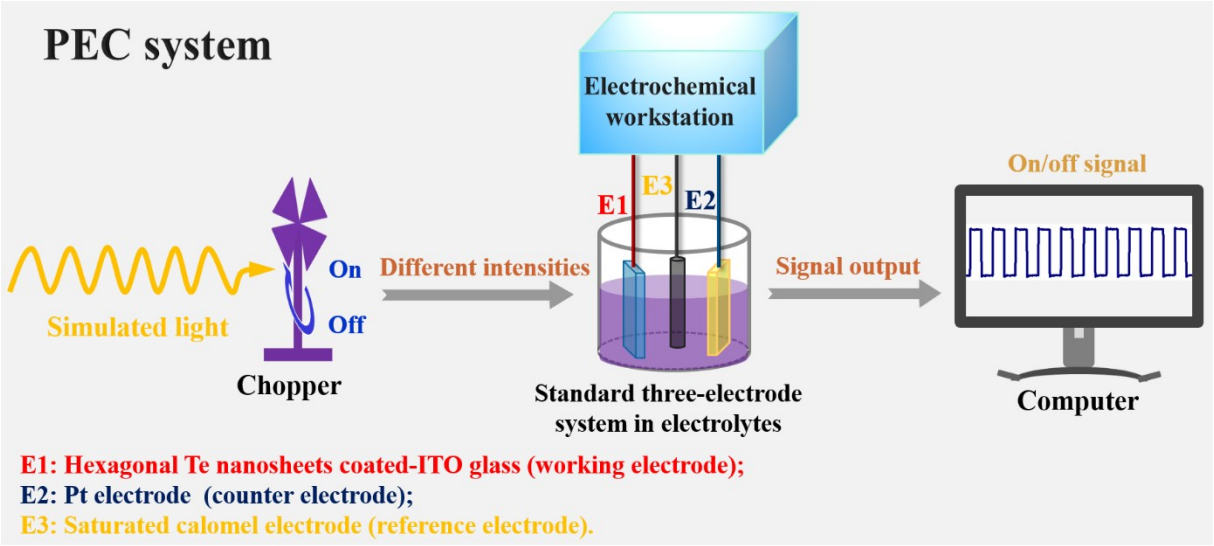


Fig. S7. (a) UV–vis–NIR absorption spectrum of hexagonal Te nanosheets in ethanol solvent; (b) The corresponding Tauc plots for calculation of band gap energy.



Scheme S1. A typical three electrodes PEC-type photodetection system used for evaluating the photoresponse behavior of the hexagonal Te nanosheets-based photodetectors.

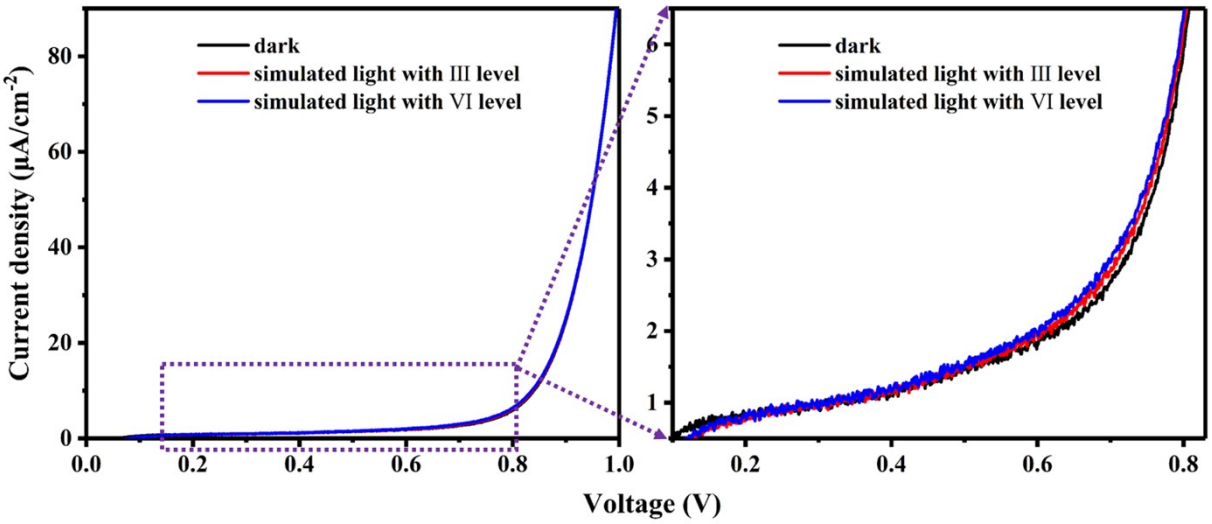


Fig. S8. Photoresponse behavior of hexagonal Te nanosheets under illumination of simulated light in 0.1 M KOH, LSV curves with a scanning speed of 0.01 V s^{-1}.

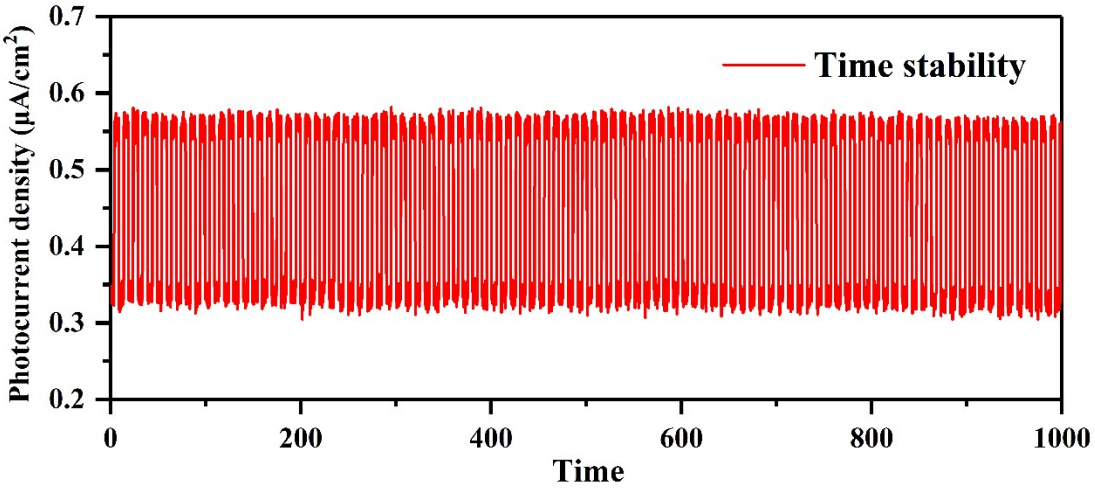


Fig. S9. Long-time on/off switching behavior measurements of the hexagonal Te nanosheets photodetector under simulated light in 0.1 M KOH at a bias of 0.6 V.

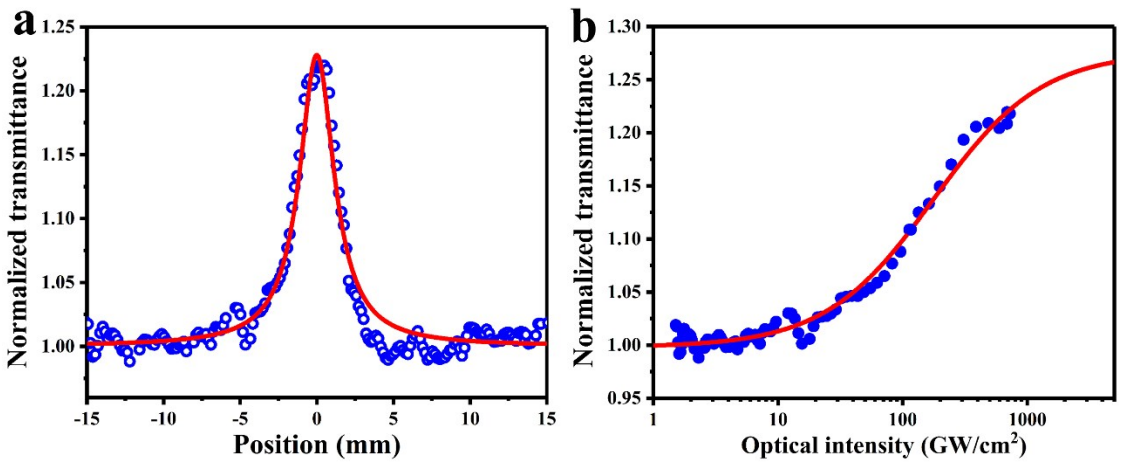


Fig. S10. (a) Open-aperture Z-scan measurements of hexagonal Te nanosheets at 1550 nm, (b) Relationship between the transmittance of the nanosheets and the intensity of femtosecond laser.

References

1. H. Zhang, Z. Zhou, B. Yang and M. Gao, *The Journal of Physical Chemistry B*, 2003, **107**, 8-13.
2. H. Zhang, Z. Cui, Y. Wang, K. Zhang, X. Ji, C. Lü, B. Yang and M. Gao, 2003, **15**, 777-780.
3. Y. Ge, Z. Zhu, Y. Xu, Y. Chen, S. Chen, Z. Liang, Y. Song, Y. Zou, H. Zeng, S. Xu, H. Zhang and D. Fan, 2018, **6**, 1701166.