Supporting Information

High Performance Polarization-sensitive Self-Powered Imaging photodetectors based on p-Te/n-MoSe$_2$ van der Waals Heterojunction with strong interlayer transition

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Fig. S1 Growth mechanism of solution-grown Te nanosheets. (a-c) Optical image of morphology evolution from the nanowire (a) through intermediate state (b) to the nanosheets (c) of Te grown by solution-grown.

Fig. S2 EDS elemental mapping for Te nanosheet. Inset: low-magnification TEM image of Te nanosheet.
**Fig. S3** Nanostructure for 2D Te nanosheet. (a-b) Crystal structure of Te nanosheet viewed from the b-axis (a) and viewed from the c-axis (b).

**Fig. S4** Material characterization of MoSe$_2$ nanosheet. (a) Low-magnification TEM image of MoSe$_2$ nanosheet. (b) HR-TEM image taken from the MoSe$_2$ nanosheet. (c) Diffraction pattern of MoSe$_2$ nanosheet.

**Fig. S5** AFM image of p-Te/n-MoSe$_2$ heterojunction device.
**Fig. S6** Raman intensity mapping collected at A_{11} (Te: 119 cm\(^{-1}\)) and A_{1g} (MoSe\(_2\): 238 cm\(^{-1}\)).

**Fig. S7** Top view (a) and side view (b) crystal structure of p-Te/n-MoSe\(_2\) heterojunction.

**Fig. S8** Time-resolved photovoltaic response of the heterostructure under different laser powers intensity of 405 nm at V = 0 V.
Fig. S9 Electrical power under varied power intensities (405 nm).

Fig. S10 Band alignment of p-Te/n-MoSe$_2$ heterostructure before contact.

Fig. S11 Extracted $I_{sc}$ and $V_{oc}$ under different laser powers intensity of 405 nm.
Fig. S12 Time-dependent photoresponse of the p-Te/n-MoSe₂ photodetector at zero bias voltage after 8 weeks storage.

Fig. S13 (a) Optical image of the fabricated MoSe₂ FET device. (b) Polarized Raman intensity mapping of MoSe₂ nanosheet as a function of wave number and incident angle. (c) Polar plot of $A_{1g}$ mode intensity in cross-polarized configurations. (d) Polar plot of $E_{12g}$ mode intensity in cross-polarized configurations. (e) Polar diagram of the polarized photocurrent for the incident wavelengths of 405 nm (0.3 mW/cm²) at 1 V. (f) Polar plots of the angle-dependent mobility as a function of the polarization angle.
Fig. S14 Polarization-sensitive photodetection of p-Te/n-MoSe$_2$ heterostructure. (a) Polarized photocurrent under 0 V for the incident wavelengths 635 nm (5.968 mW/cm$^2$). (b) Polar diagram of the polarized photocurrent for the incident wavelengths of 635 nm at zero bias voltage, and the anisotropic ratio are 13.97.

Fig. S15 The anisotropic ratio of another three constructed p-Te/n-MoSe$_2$ heterojunction device.
Table S1 Comparison of the device performances with previously reported 2D material-based photodetectors.

<table>
<thead>
<tr>
<th>Material</th>
<th>Wavelength (nm)</th>
<th>Voltage (V)</th>
<th>Responsivity ((R)) (mA(\text{W}^{-1}))</th>
<th>Detectivity ((D^*)) (Jones)</th>
<th>On/off ratio</th>
<th>Anisotropic ratio</th>
<th>Ref</th>
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<tr>
<td>Te/MoSe(_2)</td>
<td>405</td>
<td>0</td>
<td>2106</td>
<td>(\approx 10^{13})</td>
<td>(~10^5)</td>
<td>15.87</td>
<td>This work</td>
</tr>
<tr>
<td>Te</td>
<td>1550</td>
<td>1</td>
<td>(4.56 \times 10^2)</td>
<td>-</td>
<td>-</td>
<td>2.39</td>
<td>1</td>
</tr>
<tr>
<td>Te</td>
<td>400-1700</td>
<td>5</td>
<td>(1.6 \times 10^4)</td>
<td>(2.9 \times 10^9)</td>
<td>(3 \times 10^3)</td>
<td>0.95</td>
<td>2</td>
</tr>
<tr>
<td>MoS(_2)</td>
<td>400-520</td>
<td>2</td>
<td>3500</td>
<td>(2 \times 10^{11})</td>
<td>-</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Black phosphor us</td>
<td>1550</td>
<td>0.15</td>
<td>14.2</td>
<td>-</td>
<td>-</td>
<td>8.7</td>
<td>4</td>
</tr>
<tr>
<td>1T(^{1}) / T(_d) -MoTe(_2)</td>
<td>532-1060</td>
<td>0</td>
<td>0.4</td>
<td>(1.07 \times 10^8)</td>
<td>-</td>
<td>2.72</td>
<td>5</td>
</tr>
<tr>
<td>GeSe/MoS(_2)</td>
<td>380-1064</td>
<td>0</td>
<td>105</td>
<td>(1.46 \times 10^{10})</td>
<td>(3.6 \times 10^4)</td>
<td>2.95</td>
<td>6</td>
</tr>
<tr>
<td>MoS(_2) / GaAs</td>
<td>780</td>
<td>0</td>
<td>35.2</td>
<td>(1.96 \times 10^{13})</td>
<td></td>
<td>4.8</td>
<td>7</td>
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References