Supplementary Information (SI) for Journal of Materials Chemistry C.

SUPPORTING INFORMATION

Wide-Spectrum Self-Powered Photoelectric Detection Based on The Type-II Heterostructure of $MnPSe_3/MoS_2$

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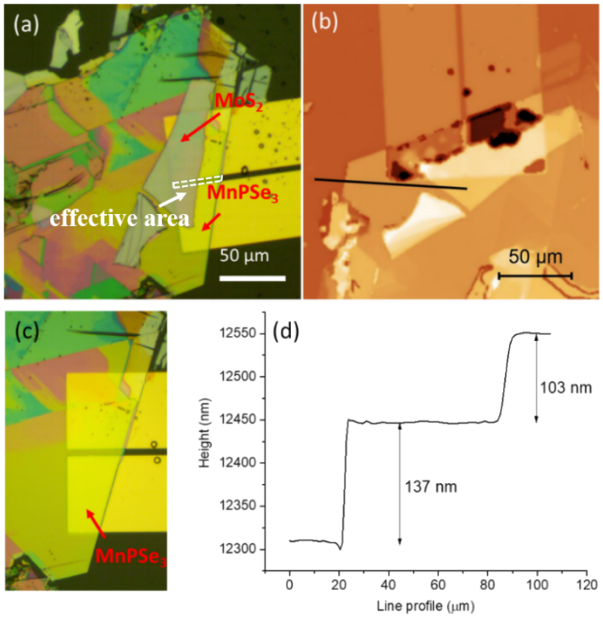

Fig. S1 (a) OM image of the PG-PD described in Figure 3. (b) and (d) Thickness characterization of the exfoliated flakes on the device by the white light interferometer. The line profile in (d) corresponds to the black line marked in (b). (c) OM image of $MnPSe_3$-based PD described in Figure S3.

The thicknesses of $MnPSe_3$ and MoS_2 flakes were measured to be 137 nm and 103 nm, respectively. The $MnPSe_3$ flake in Figure S1c corresponds to the same flake in the device shown in Figure S1a.

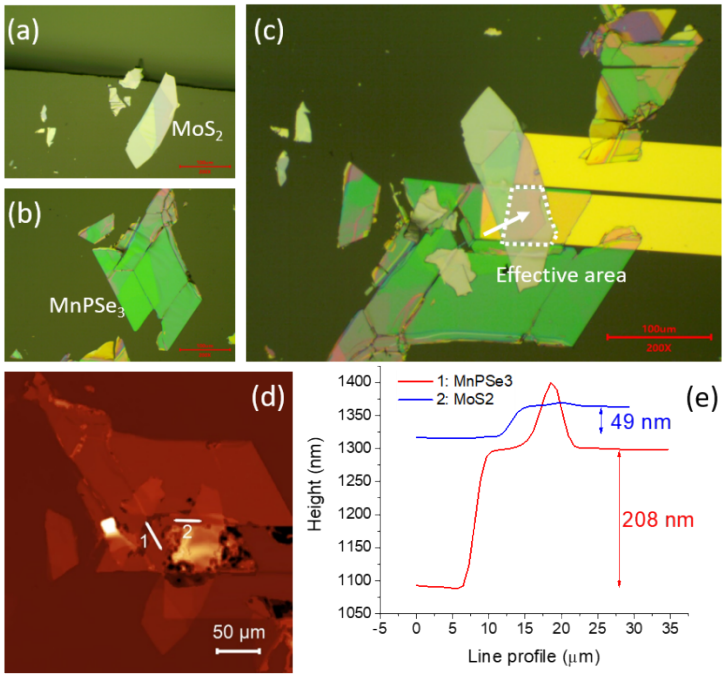

Fig. S2 OM images of the exfoliated (a) MoS_2 and (b) $MnPSe_3$ flakes prior to the dry transfer onto the electrodes. (c) OM image of the VS-PD based on $MnPSe_3/MoS_2$ and (e) the thickness measurement of $MnPSe_3$ and MoS_2 by the white light interferometer.

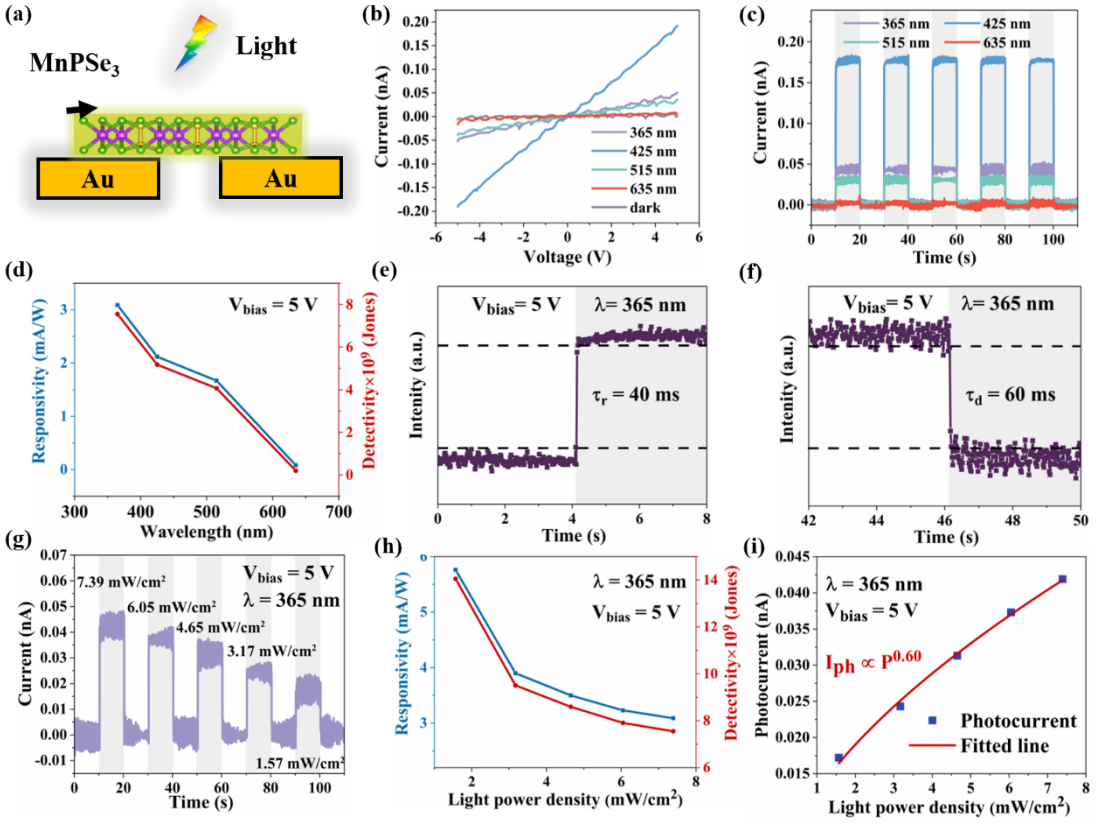

Fig. S3 (a) Schematic device structure of the $MnPSe_3$-based PD. (b) The current-voltage (I-V) curves of the device under illumination of 365, 425, 515 and 635 nm wavelength light sources. (c) Transient photocurrent measurement curves of the device illuminated by different light sources biased at 5 V and (d) the correspondingly calculated values for responsivity (R) and specific detectivity (D^*). (e) The rise and (f) decay times of the $MnPSe_3$-based PD under the irradiation of 365 nm wavelength light. (g) The light-power-density-dependent transient photocurrent, (h) the correspondingly calculated R and D* values, and (i) the correlation plot between the light power density and the photocurrent values under 365 nm light irradiation at 5 V.

The photoelectric responses of a $MnPSe_3$-based PD with the exfoliated $MnPSe_3$ flake thickness of 137 nm (Figure S3) was measured. The schematic device structure is shown in Figure S3a. According to the obtained I-V tests in Figure S3b, it can be seen that the device has an ultraviolet-visible spectral response ranging from 365 nm to 635 nm. The measured dark current demonstrated to be as low as the magnitude order of 10^{-12} A, indicating low noise characteristics and low energy consumption of the device.

Figure S3c shows the stable temporal photoelectric response curves of the device at different wavelengths, and the device's photocurrent at 425 nm demonstrated to be significantly higher the others. The maximum on/off ratio (10^2) was obtained when the device was illuminated by the 425 nm light. As displayed in Figure S3d, the maximum R and D^* values for the device are 3 mA/W and 7.5×10^9 Jones, respectively, appearing at 365 nm. The response times of the device at 365 nm are illustrated in Figure S3e and Figure S3f. At 5 V bias, τ_r and τ_d at 365 nm turned to be 40 ms and 60 ms, respectively. In Figure S3f, we used the equation $I_{ph} = P^{\alpha}$ to fit the data points of I_{ph} related to power density under the irradiation of 365 nm light source[1]. Here the parameter α is the fitting coefficient that could be utilized for evaluating the interface state of the device. The closer α approaches to 1, the more ideal the interface state is[2-4]. In Figure S3f, the calculated value of α is 0.60, indicating a certain amount of defects existing at the interface between $MnPSe_3$ and gold electrodes[2-4].

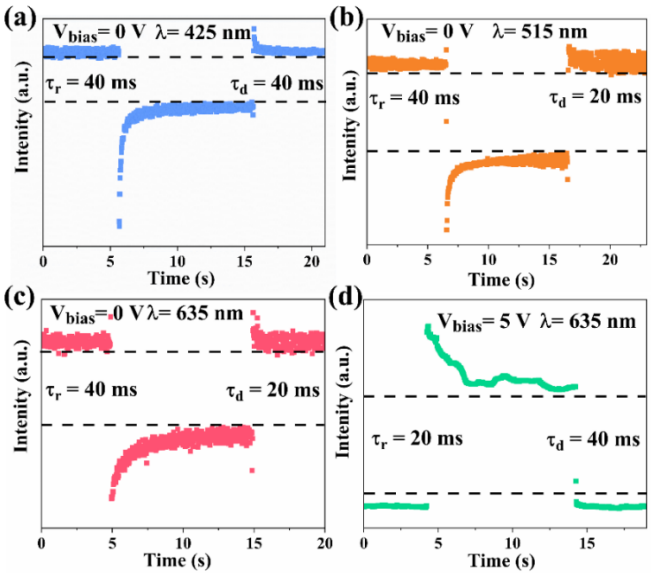

Fig. S4 Rise and decay times of the VS-PD device illuminated by 425 nm, 515 nm, and 635 nm light sources, with (a-c) at 0 V and (d) at 5 V, respectively.

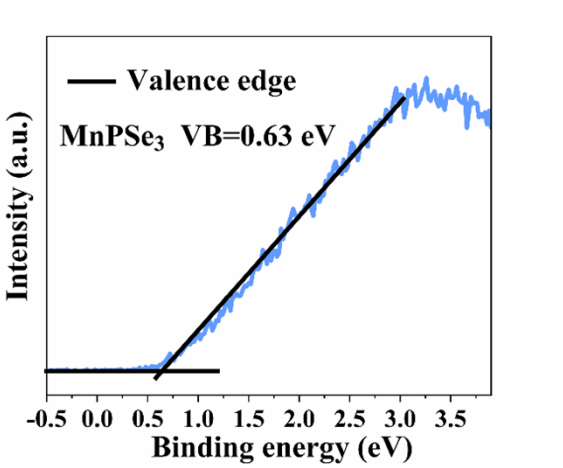

Fig. S5 The valence band spectrum of $MnPSe_3$

The valence band spectrum of $MnPSe_3$ is shown in Figure S5. The energy difference between the valence band maximum (VBM) and the Fermi level here was measured to be 0.63 eV. According to the reported conduction band position (-5.27 eV) and a valence band position (-3.27 eV) obtained by UPS measurement[5, 6], the work function for $MnPSe_3$ is supposed to be −4.64 eV.

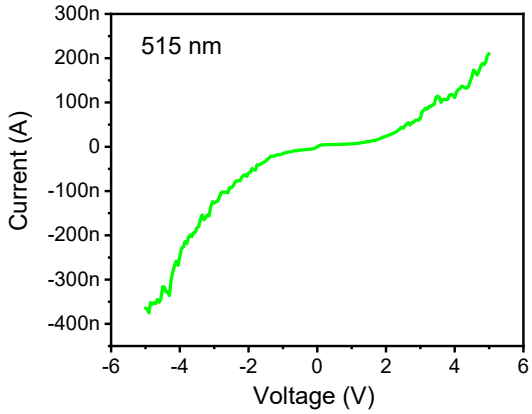

Fig. S6 I-V test of a Au/MoS_2/Au photodetector illuminated by a 515 nm laser diode.

Table. S1 Optical power densities of light sources with different wavelengths

Power density(mW/cm^2) / Wavelength(nm)	20%	40%	60%	80%	100%
254	/	/	/	/	0.558
365	1.57	3.17	4.65	6.05	7.39
425	/	/	/	/	43.6
515	2.7	4.6	6.4	8.1	9.3
635	/	/	/	/	8.5
700	1.0	2.7	4.6	6.48	8.36
780	/	/	/	/	9.94
880	/	/	/	/	18.8
1020	/	/	/	/	14.9

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