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Supporting Information

Type-I PtS_2/MoS_2 van der Waals Heterojunction with Tunable Photovoltaic Effect and High Photosensitivity

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Experimental section:

Device Fabrication

The type-I PtS_2/MoS_2 vdWH device proposed in this work were fabricated by a dry transfer method using PDMS as carrier. First, thick PtS_2 and thin MoS_2 flakes were exfoliated from the bulk counterparts using Scotch tape and then transferred onto a silicon substrate where is covered with 300 nm thick SiO_2. Next, the electrode patterns were defined by electron-beam lithography (EBL, eLINE Plus, Raith), and Ti/Au (15/50 nm) metals were deposited on the silicon substrate by electron beam evaporation and thermal evaporation, respectively. Finally, the plated device was treated by a standard lift-off process in acetone.

Device Characterization and Measurement

The type-I PtS2/MoS2 vdWH device was investigated by an optical microscope (WMJ-9688). Raman spectra were measured at room temperature by a Raman/photoluminescence (PL) system (FST2-Ahdx-DZ) equipped with a monochromator and 532 nm laser source. The thickness of the layers and the surface potential were obtained simultaneously by KPFM measurement (Hitachi AFM5500M). The electrical properties of the fabricated devices were measured in a probe station (HFS600E-PB4) using a semiconductor device parameter analyzer (Keithley 4200A-SCS). For photoresponse measurements, the 685 nm laser was keep irradiating on the effective area of the device. All the device measurements were conducted at room temperature in an ambient environment.

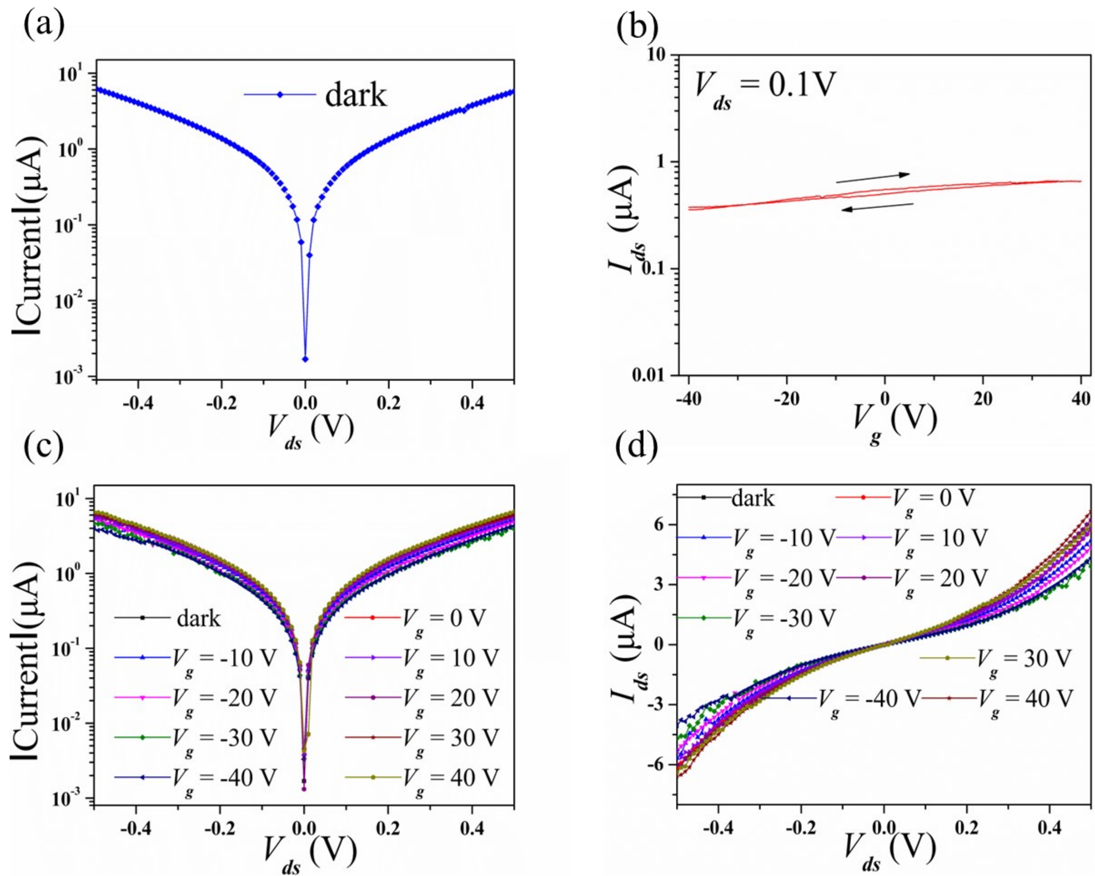

Figure S1. Electrical characterizations of the individual PtS_2 FET. a) I_{ds} - V_{ds} characteristics of the PtS_2 FET in the dark. b) Transfer curve of the PtS_2 FET at V_{ds} = 0.1 V. I_{ds} - V_{ds} curves of the PtS_2 FET under different gate voltages in c) logarithmic scale and d) liner scale.

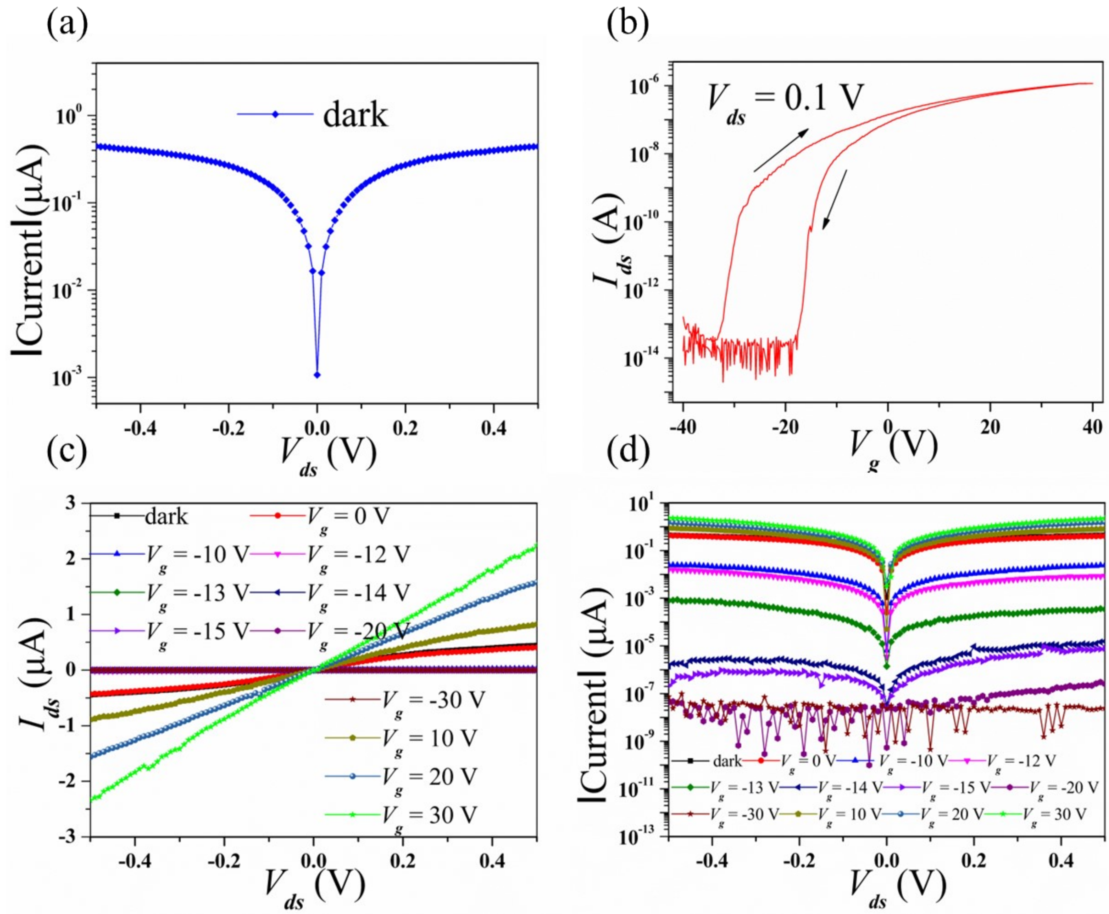

Figure S2. Electrical characterizations of the individual MoS_2 FET. a) I_{ds} - V_{ds} characteristics of the MoS_2 FET in the dark. b) Transfer curve of the MoS_2 FET at V_{ds} = 0.1 V. I_{ds} - V_{ds} curves of the MoS_2 FET under different gate voltages in c) liner scale and d) logarithmic scale.

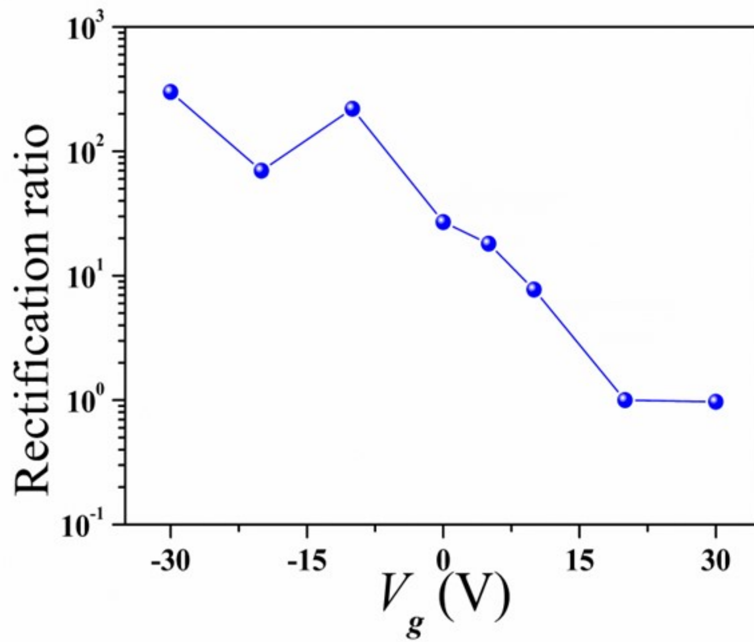

Figure S3. The forward rectification ratio of PtS_2/MoS_2 heterojunction at various gate voltages.

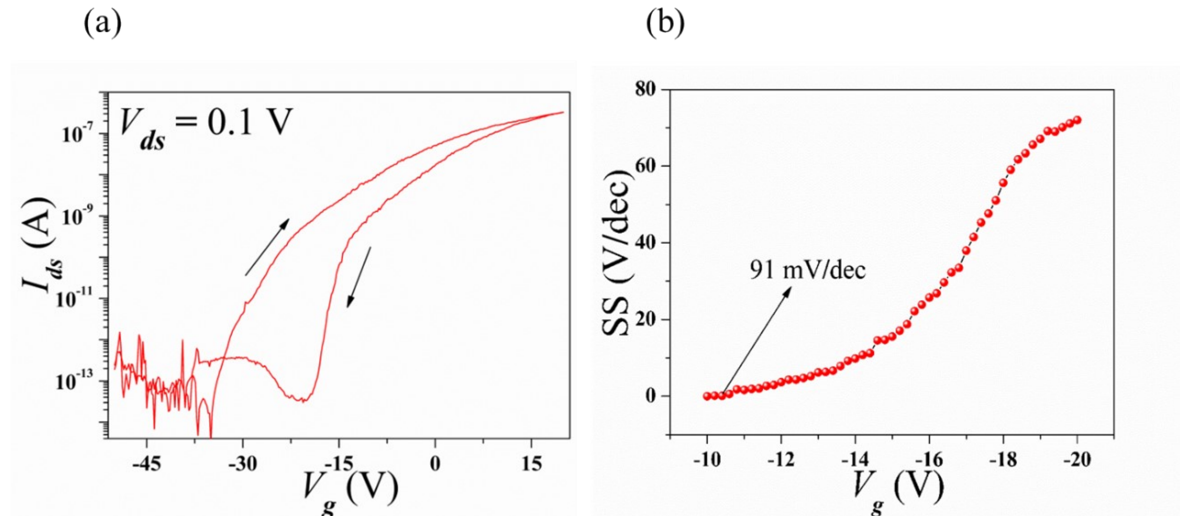

Figure S4. a) I_{ds} - V_g transfer curve of the PtS_2/MoS_2 vdWH device in the main text. b) Subthreshold swing (SS) of the PtS_2/MoS_2 vdWH device in the main text as a function of V_g.

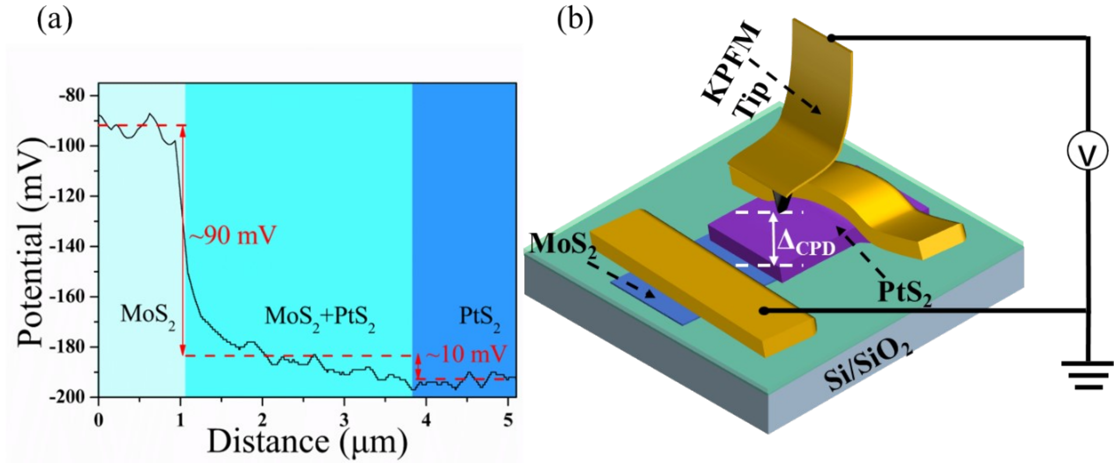

Figure S5. a) The surface potential profile in the region of MoS_2, MoS_2/PtS_2, and PtS_2. b) The schematic diagram of the measurement of KPFM, the value of Δ_{CPD} is the surface potential of tip mental of Rh (Φ_{Tip} = 4.9 eV) minus the surface potential of the heterojunction ($\Delta_{CPD} = \Phi_{Tip} - \Phi_{Sample}$).

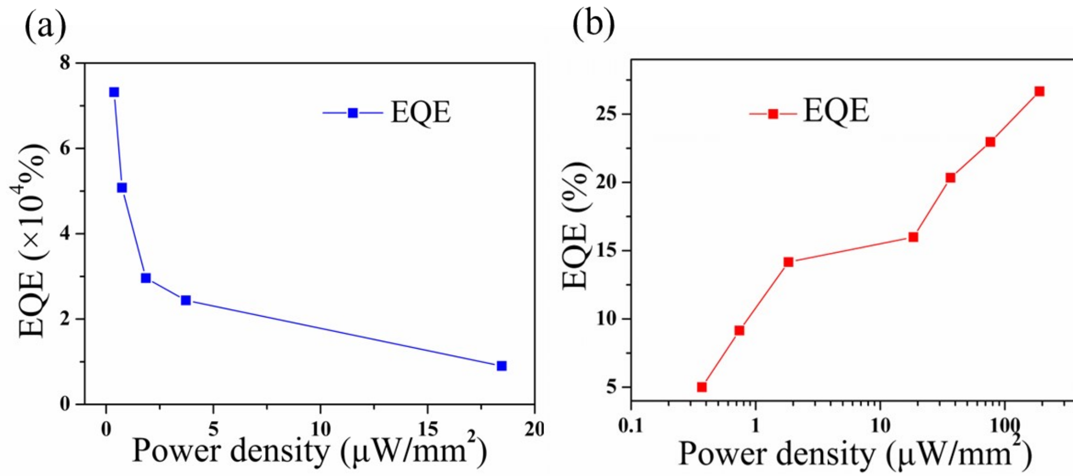

Figure S6. The calculated EQE values illuminated by 685 nm light at a) V_g = 0 V, V_{ds} = 0.1 V and b) V_g = -40 V, V_{ds} = 0.1 V.

Table S1. Comprehensive comparison of the critical parameters of fabricated PtS_2/MoS_2 vdWHs with previously reported MoS_2 based photodetectors

Materials	Wavelength (nm)	Condition	R ($A\ W^{-1}$)	D* (Jones)	EQE (%)	Response time	Ref.
PtS_2/MoS_2	685	$V_g = 0, V_{ds} = 0.1$ V	403	1.07×10^{11}	7.32×10^{4}	24/21 ms	This Work
MoS_2	532	$V_g = 0, V_{ds} = 1$ V	15.6			100ms	1
ZnO-QDs/MoS_2	635	$V_g = 0, V_{ds} = 1$ V	0.084	1.05×10^{11}	25.7	1.5/1.1s	2
Si/MoS_2	532	$V_g = 0, V_{ds} = 3$ V	117	1×10^{9}	55	74/115ms	3
GaSe/MoS_2	450	$V_g = 0, V_{ds} = 0$	0.9	6.5×10^{9}		5/5 ms	4
Graphene/MoS_2	540	$V_g = 0, V_{ds} = 5$ V	0.835			20/30 ms	5
$PdSe_2/MoS_2$	532	$V_g = 0, V_{ds} = 0$	9	3×10^{10}		125/7 ms	6
$MoTe_2/MoS_2$	470	$V_g = 0, V_{ds} = 0$	0.322		85	25 ms	7

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