Supporting Information

Lateral Homojunction of WSe_2 through Contact Surface Engineering with SF_6 Plasma Etching

Yubao Li, * Huiping Wang, Xiaolin Yang, and Wei Zhang *

Hebei Key Laboratory of Photo-Electricity Information and Materials, College of Physics Science and Technology, Hebei University, Baoding 071002, P.R. China

* Corresponding authors. Email: liyubao@hbu.edu.cn (Y. Li), zhangw@hbu.edu.cn (W. Zhang)

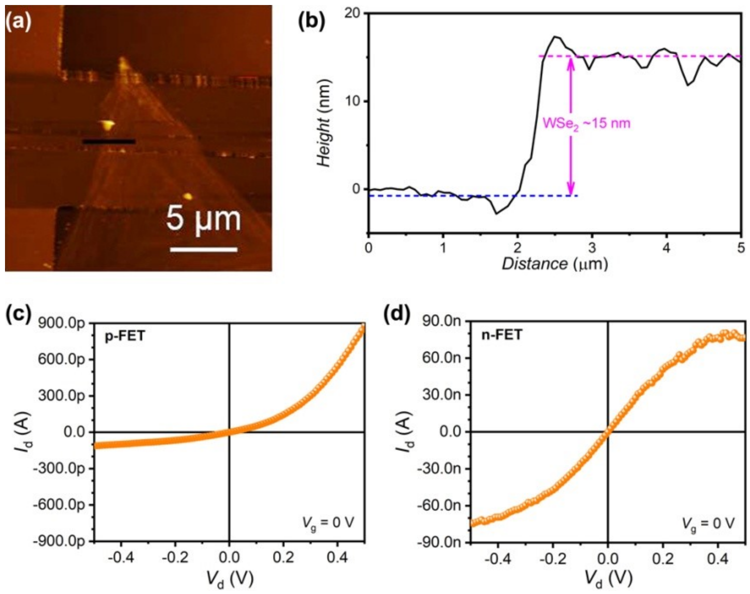

Fig. S1 Characterization results of the n-FET in Fig. 2(c) and the p-FET in Fig. 2(a) of main text. **(a)** and **(b)** AFM image and height profile of WSe_2 nanosheet channel of n-FET along the black line drawn in (a); **(c)** and **(d)** IV plots of p-FET/n-FET without gating.

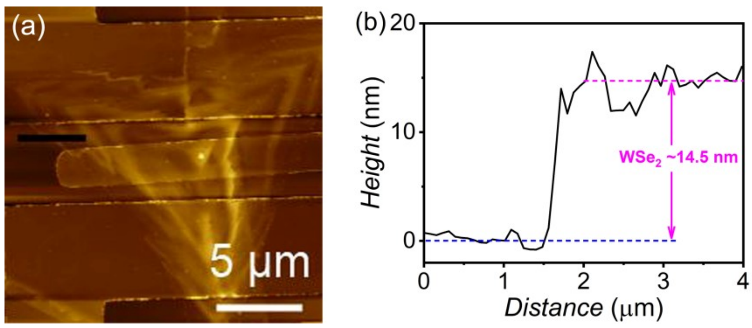

Fig. S2 AFM characterization results of two diodes shown in Fig. 4 of main text. **(a)** AFM image; **(b)** Height profile of WSe_2 nanosheet channel along the black line in (a).

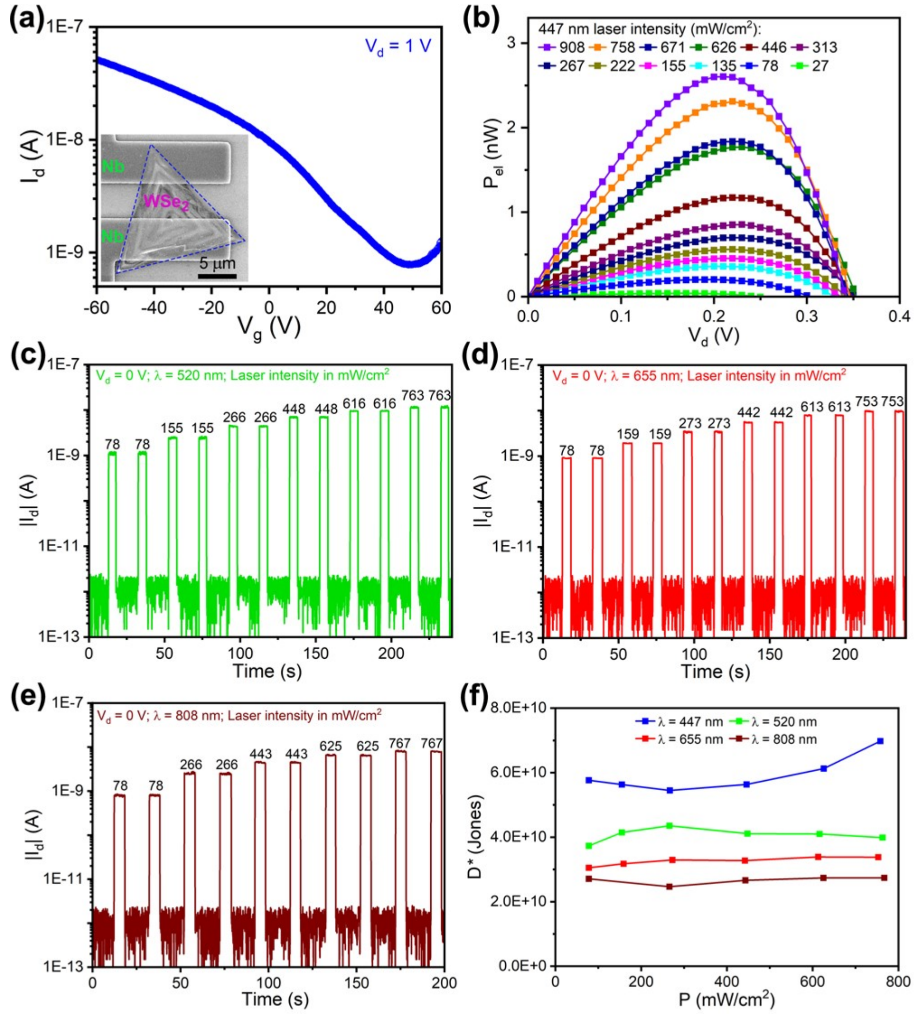

Fig. S3 Characterization results of the p-n device shown in Fig. 5 of main text**.** **(a)** I_d-V_g transfer curve of the p-FET device (inset: SEM image) which was used to further build the p-n device shown in Fig. 5 of main text; **(b)** Electrical power output curves of photodiode for 447 nm illuminations; **(c)-(e)** Time-dependent photocurrent plots under the illuminations of 520/655/808 nm at denoted intensities without external bias; **(f)** Corresponding specific detectivity plots of the PV-mode photodiode for 447/520/655/808 nm.

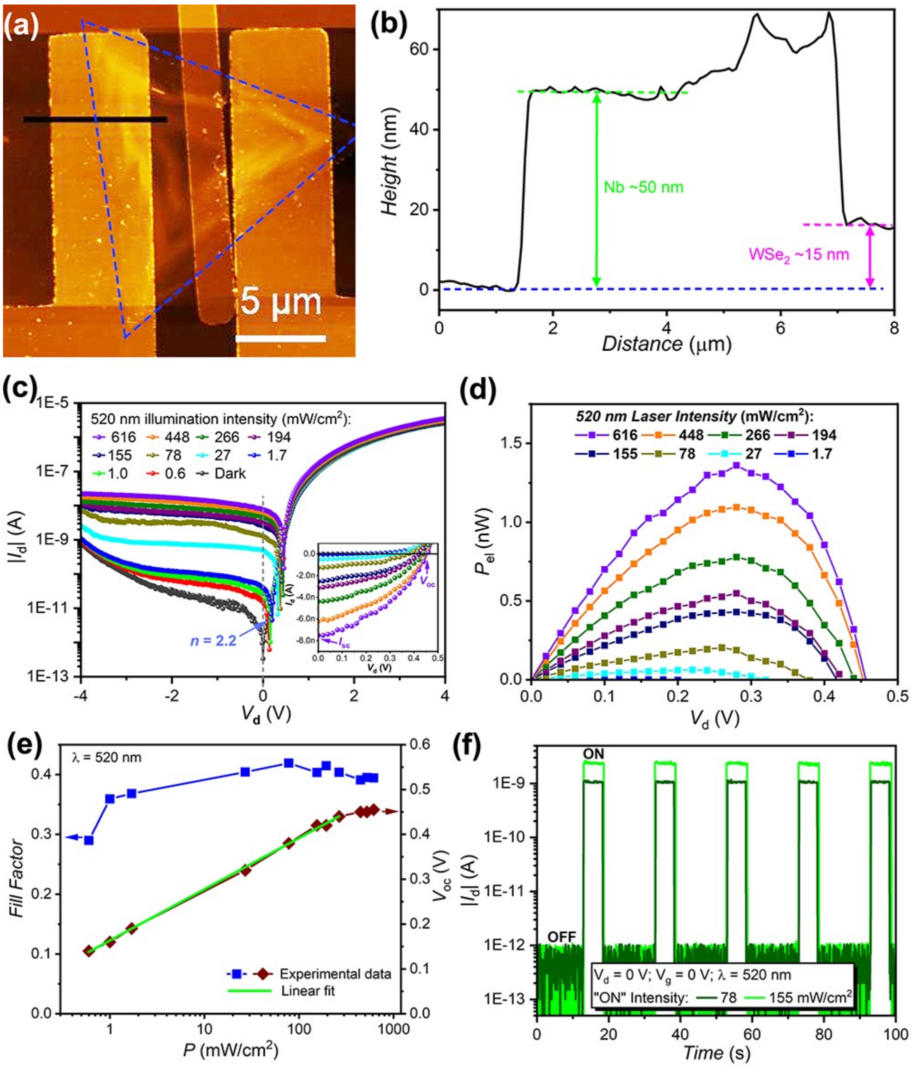

Fig. S4 Characterization results of a single p-n homojunction fabricated from the p-FET in Fig. 2(a). **(a)** AFM image; **(b)** Corresponding height profile along the black line drawn in (a); **(c)** Dark and photo-induced I-V plots under 520 nm laser illumination at different intensities (the inset: the fourth quadrant portion of I-V linear plots); **(d)** Electrical power output curves under 520 nm illumination at different intensities; **(e)** Fill factor & open circuit voltage plots as a function of light intensity; **(f)** Time-dependent photocurrents with periodic illuminations with 520 nm laser at two different intensities.

Fig. S4 presents the photoelectric properties of a WSe_2-based diode originated from the p-FET shown in Fig. 2(a). As illustrated in Fig. 1 of main text for the processing of single p-n device, pre-fabricated p-FET was transformed into a p-n homojunction by inserting a third Nb-electrode to be slightly overlapping with one existing electrode (i.e. the right-side electrode). Fig. S4(a) displays an AFM image of p-n device, and corresponding height profile recorded along the black line is plotted in Fig. S4(b), showing that the original Nb electrode is about 50 nm thick and WSe_2 nanosheet is about 15 nm thick (containing 24 layers). Fig. S4(c) displays the I-V plots of diode measured in the dark or under the illuminations of 520 nm light at specified intensities, identifying its clear rectification characteristics. The ideal factor of diode is measured to be 2.2 in the dark, indicating a dominant recombination within its space charge region. In the dark, the forward current is 50 nA at +1 V (466 nA at +2 V), and the reverse current is about 15 pA at -1 V (35 pA at -2 V), so the diode's rectification ratio is about 3×10^3 for ±1 V and 1.3×10^4 for ±2 V, respectively. I-V curves under 520 nm illuminations with various intensities between 0.6-616 mW/cm^2 all disclose pronounced PV characteristics. Corresponding linear I-V curves in the fourth quadrant are displayed as lower-right inset in Fig. S4(c). Under stronger illumination, both V_{oc} and I_{sc} are climbing up higher. Under a weak illumination at 1 mW/cm^2, the diode responds with a V_{oc} of 160 mV and an I_{sc} of 26 pA; when the illumination is intensified to 616 mW/cm^2, the V_{oc} reaches to 450 mV and the I_{sc} to 7.5 nA. Based on the data in Fig. S4(c), corresponding P_{el} plots for 520 nm are presented in Fig. S4(d), showing higher maximum output electrical power (P_{max}) for stronger illuminations. As presented in Fig. S4(e), a linear fit is obtained for V_{oc} in the range from 0.6 mW/cm^2 to 266 mW/cm^2 where a saturation in V_{oc} at about 450 mV appears, and a fill factor about 0.4 is obtained for relatively-strong illuminations. Fig. S4(f) demonstrates that the WSe_2 lateral homojunction is capable of high-quality photoelectric response to 520 nm excitement.

Table S1 Comparison of self-powered (V_d = 0 V & V_g = 0 V) photodetection performance between this work (★) and other recently-reported multilayer WSe_2-based lateral homojunctions.

2D WSe_2	Approach	Junction type	λ (nm)	*FF*	V_{oc} (mV)	*R* (mA/W)	τ_{rise} (μs)	Ref.
Exfoliated	Ar/O_2-plasma doping	Lateral	450	NA	340	100	0.264	14
Exfoliated	Contact doping	Semi-Lateral	532	0.26	140	197	120	16
Exfoliated	Thickness modulation	Lateral	532	0.31	490	11	180	31
Exfoliated	Contact engineering	Lateral	520	0.66	450	283	1.27	40
CVD	Contact doping	Lateral	520	0.4	520- 620	500	10	17
CVD	In-situ defect-doping	Lateral	532	NA	120	27.8	21800	29
CVD	Contact engineering	Lateral	532	NA	370	20.31	42.9	41
CVD	SF_6-plasma doping	Lateral	447	0.4	350- 450	~130	10	★