Journal Name

Supporting Information

Gate-tunable and High Optoelectronic Performance in Multilayer WSe₂ P-N Diode

Yujue Yang, †a Nengjie Huo †a and Jingbo Li *a,b
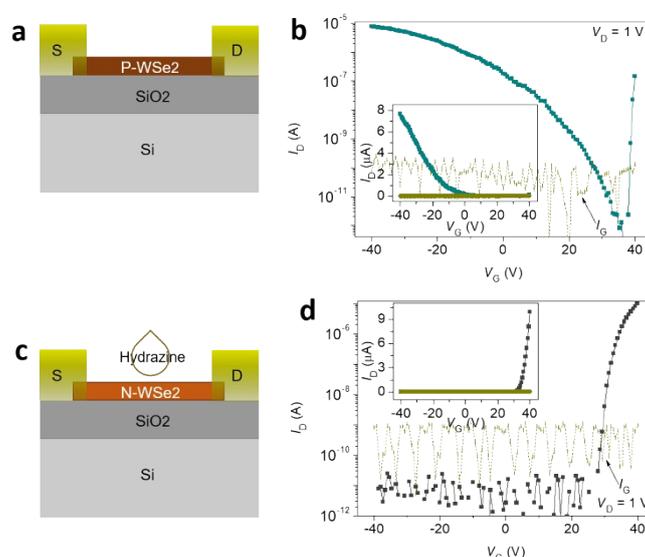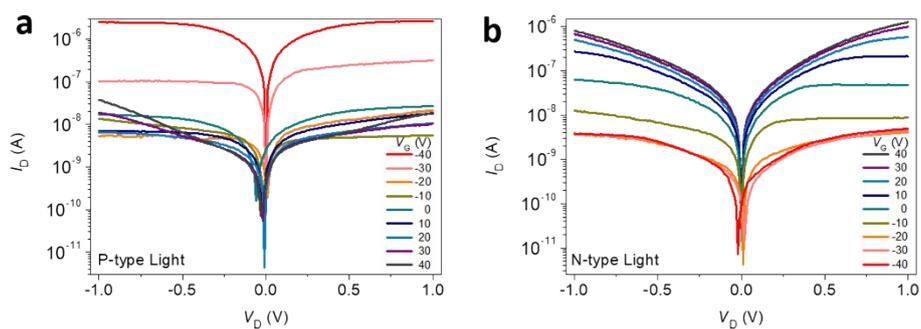

Fig. S1 (a) Schematic diagram of pristine WSe₂ transistor. (b) Transfer curves of the device showing the main P-type behaviour with ON-OFF ratio up to 10[7]. Insert is the same curve with linear scale. (c) Schematic diagram of WSe₂ transistor after chemically doping. (d) Transfer curves of the device showing the well N-type behaviour with ON-OFF ratio over 10[6]. Insert is the same curve with linear scale. The yellow curves in (b) and (d) represent the leakage current (I_G-V_G), which is negligible compared to the source-drain current, ensuring the measured current signal is from the WSe₂ channel.
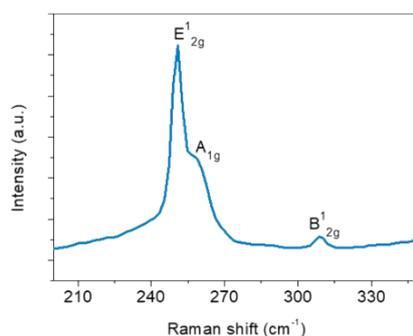

Fig. S2 Raman spectra of the WSe₂, showing the typical phonon mode of multilayer WSe₂. The two adjacent modes at around 250 nm are assigned to E^1_{2g} and A_{1g} modes, respectively. The normally inactive mode B^1_{2g} mode can emerge at multilayer WSe₂ but disappear at monolayer. Our Raman result is consistent with previous reports.[S1,S2]

Fig. S3 (a) Output curves of pristine P-type WSe$_2$ transistors under light illumination. (b) Output curves of the doped N-type WSe$_2$ transistors under light illumination. The photovoltaic effect is absence in both case.
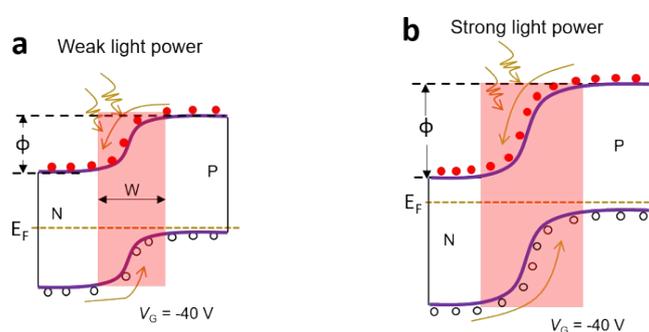
Fig. S4 Schematic diagram of band structures in the P-N junctions at V_G of -40 V under (a) weak and (b) strong light illumination. The red shadow region represents the depletion region of the P-N junctions.
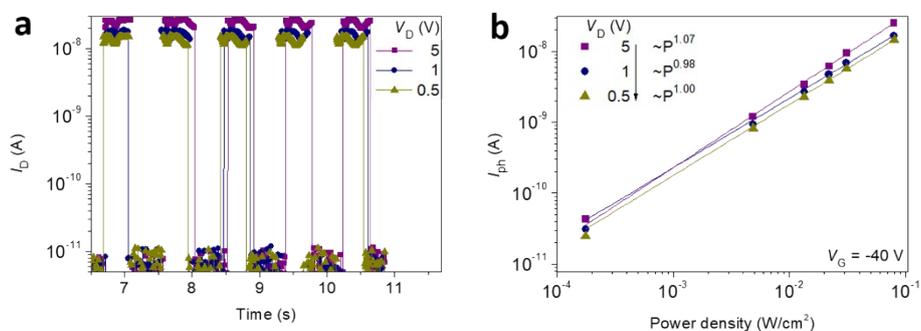
Fig. S5 (a) Temporal response the WSe$_2$ photodiode at different V_D, showing the fast speed below 4 ms and light switching ratio over 10^3. (b) Photocurrent of the device as a function of incident light power density at V_G of -40 V and different V_D. The linear curves are the power-law fits, describing fitted α of ~1.
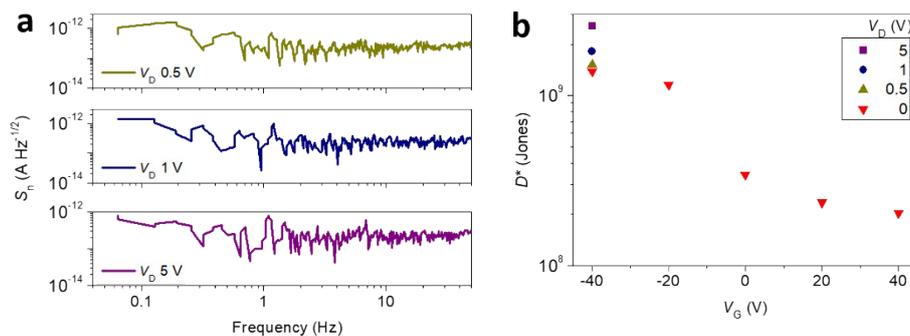
Fig. S6 (a) Noise spectral density S_n of the photodiode at different V_D. To obtain S_n, the dark current traces were measured with the Agilent system (Agilent B1500A) under exactly the same conditions as the optical measurements were performed (same V_G and V_D) at a sampling rate of 250 Hz. We obtained noise spectral density by calculating the Fourier transformation of dark current traces. (b) The calculated specific detectivity D^* at different V_D and V_G, showing the maximum D^* of 2.5×10^9 Jones at V_D of 5 V and V_G of -40 V.

Supplementary References

1. H. Li, G. Lu, Y. Wang, Z. Yin, C. Cong, Q. He, L. Wang, F. Ding, T. Yu and H. Zhan, *Small*, 2013, **9**, 1974.

2. N. Huo, S. Tongay, W. Guo, R. Li, C. Fan, F. Lu, J. Yang, B. Li, Y. Li and Z. Wei, *Adv. Electron. Mater.*, 2015, **1**, 1400066.