

## Supporting Information

### *Homogeneous In-plane WSe<sub>2</sub> P-N Junction for Advanced Optoelectronics Devices*

*Dewu Yue<sup>a</sup>, Xin Ju<sup>b,\*</sup>, Tao Hu<sup>a</sup>, Ximing Rong<sup>c</sup>, Xinke Liu<sup>c</sup>, Xiao Liu<sup>c</sup>, Hong Kuan Ng<sup>b</sup>, Dongzhi Chi<sup>b</sup>, Xinzhong Wang<sup>a,\*</sup>, Jing Wu<sup>b,d,\*</sup>*

<sup>a</sup> Information Technology Research Institute, Shenzhen Institute of Information Technology, Shenzhen, 518172, China

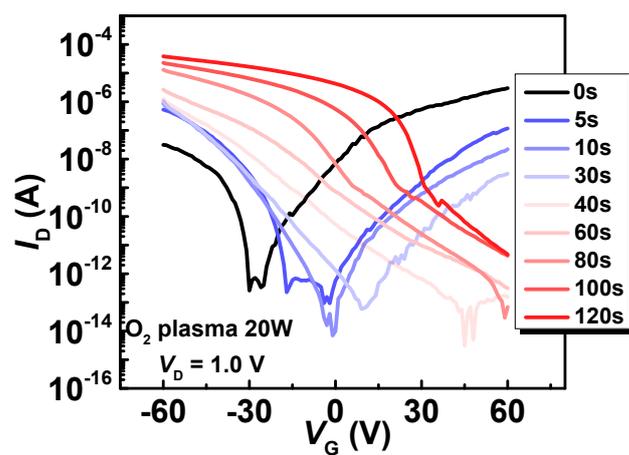
<sup>b</sup> Institute of Materials research and Engineering, 2 Fusionopolis Way, Innovis, #08-03, Agency for Science, Technology and Research, Singapore

<sup>c</sup> College of Materials Science and Engineering, Shenzhen Key Laboratory of Special Functional Materials, Shenzhen Engineering Laboratory for Advanced Technology of Ceramics, Guangdong Research Center for Interfacial Engineering of Functional Materials, Shenzhen University, Shenzhen 518060, China;

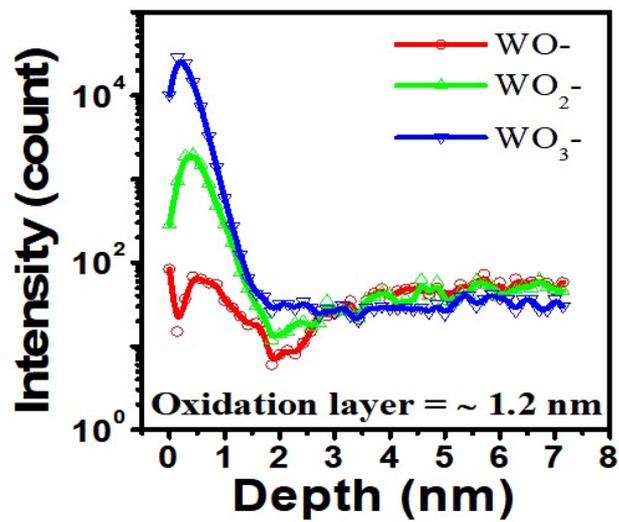
<sup>d</sup> Department of Materials Science and Engineering, National University of Singapore

\*Corresponding authors:

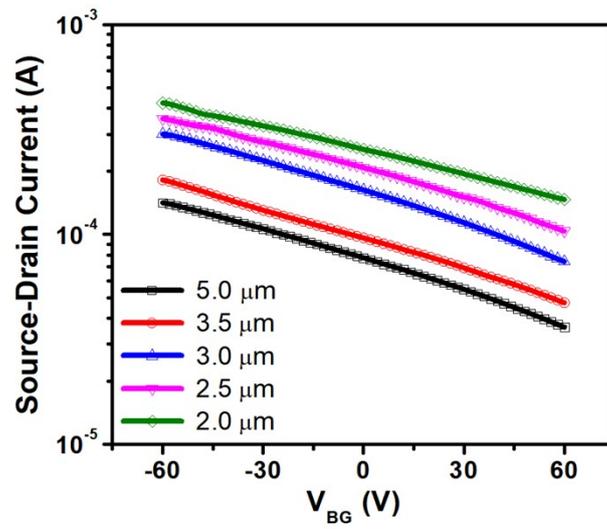
E-mail addresses: [ju\\_xin@imre.a-star.edu.sg](mailto:ju_xin@imre.a-star.edu.sg) (X. Ju); [wangxz@sziit.com.cn](mailto:wangxz@sziit.com.cn) (X. Wang); [wujing@imre.a-star.edu.sg](mailto:wujing@imre.a-star.edu.sg) (J. Wu)



**Fig. S1** The transfer curve of WSe<sub>2</sub> transistor at the power of 20 W with different plasma treatment times from 5 to 120 s.



**Fig. S2** The secondary-ion mass spectrometry (SIMS) test results confirm the surface oxidation of  $\text{WSe}_2$  and demonstrate the depth of the oxide layer is around  $\sim 1.2$  nm.  $\text{WO}_x$  ( $\text{WO}^-$ ,  $\text{WO}_2^-$ ,  $\text{WO}_3^-$ ) was formed after  $\text{O}_2$  plasma treatment.



**Fig. S3** The transfer characteristics of the WSe<sub>2</sub> with different channel length.

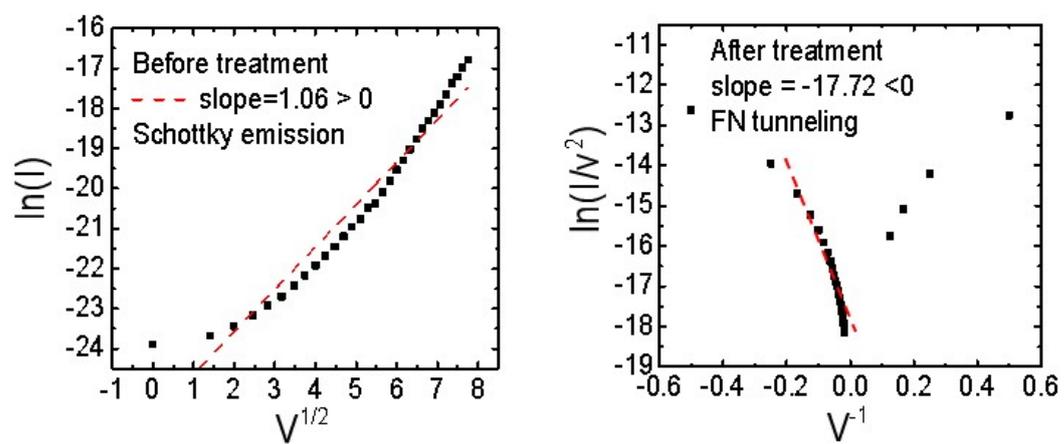
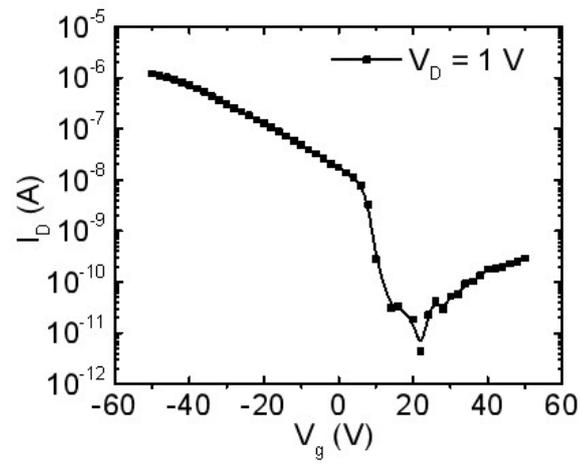
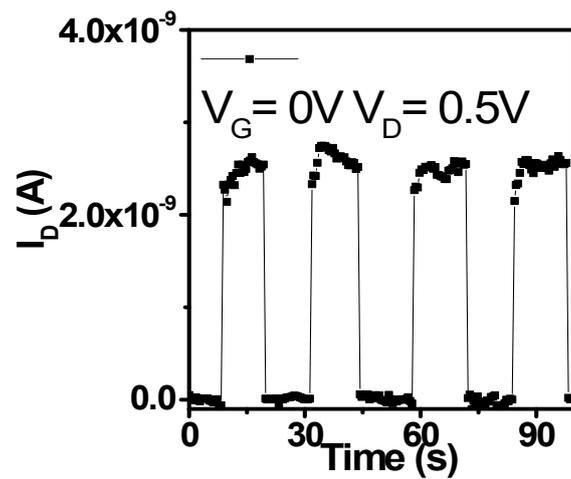


Fig. S4 I-V curves indicate the Schottky emission model and the F-N tunneling model before and after oxygen plasma treatment, respectively.



**Fig. S5** The transfer characteristics of the WSe<sub>2</sub> devices test from -50 V to 50 V.



**Fig. S6** The photoresponse performances of the WSe<sub>2</sub> p-n junction photodetectors at the gate voltage of 0 V with time-dependent photocurrent.