Supporting Information for: Multimodal Photodiode and Phototransistor Device Based on Two-Dimensional Materials

Seon Namgung, Jonah Shaver, Sang-Hyun Oh, and Steven J. Koester*

Department of Electrical and Computer Engineering, University of Minnesota

200 Union Street SE, Minneapolis, Minnesota 55455, United States

* *Address correspondence to: skoester@umn.edu*

Photocurrent maps measured with different wavelengths

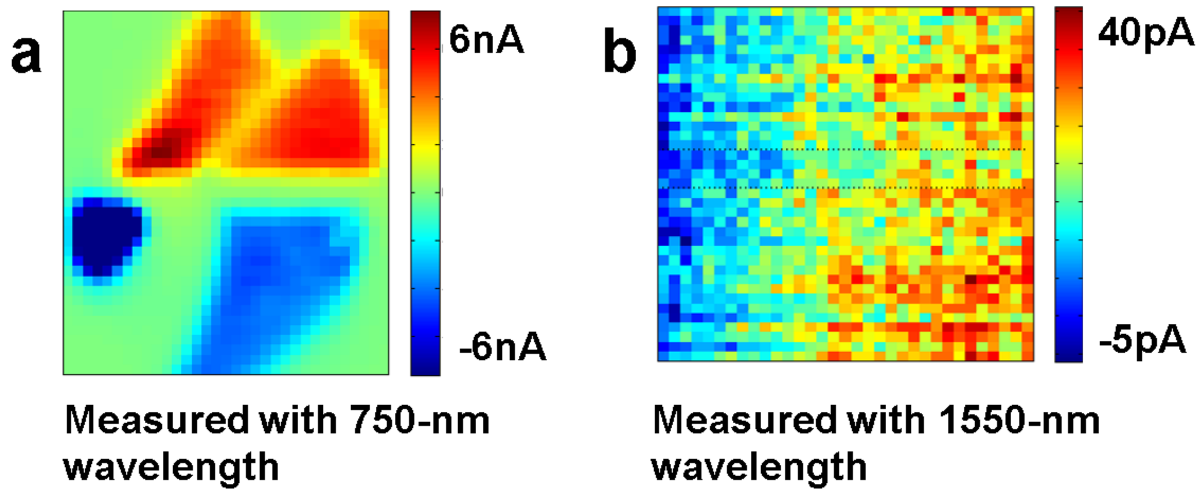

Figure S1. Photocurrent of the MoS_2 device excited with different wavelength, λ, lasers. Spatial photocurrent mapping excited with at (a) λ = 785 nm and (b) λ = 1550 nm. No photocurrent is observed with excitation energy lower than the bandgap of MoS_2 (λ = 1550 nm in this case), indicating photocurrent generation from band-to-band absorption in MoS_2.

Photocurrent measured on different regions of the WSe_2 bimetallic device

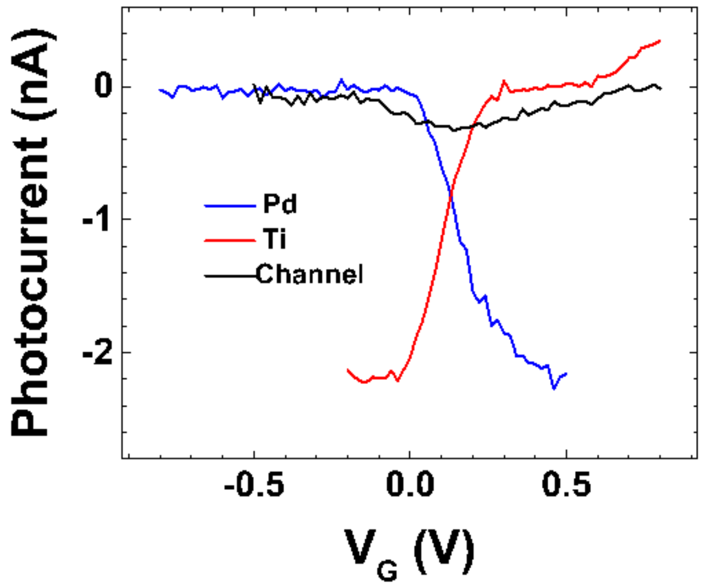

Figure S2. Photocurrent measured on different regions in the WSe_2 device at $V_D = 0$ as a function of V_G.

Schottky barrier height determination using multi-electrode structure

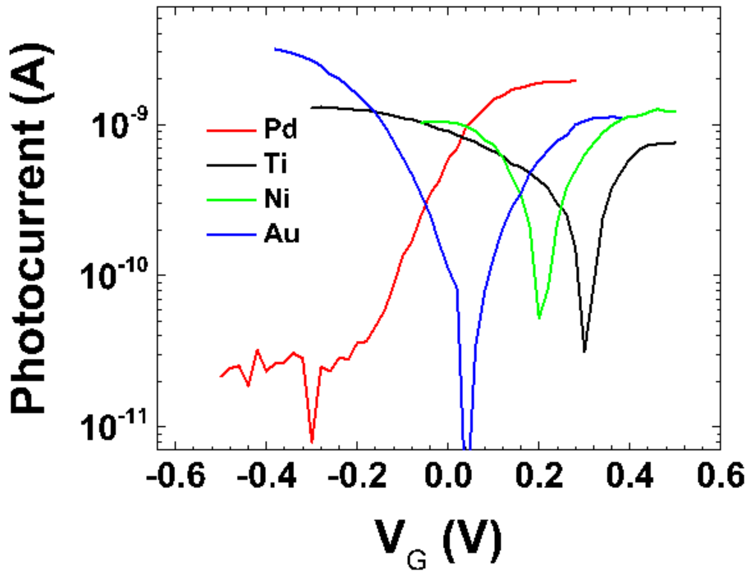

Figure S3. Semi-log plots of photocurrent on a single WSe_2 flake over four different electrode metals as a function of V_G at $V_D = 0$. The relative Schottky barrier height difference of WSe_2 on each metal can be extracted. The results reveal the Schottky barrier to the conduction band increases in the following order: Ti, Ni, Au, and Pd. The relative Schottky barriers to the Ti barrier height are determined to be 0.11 eV (Ni), 0.24 eV (Au) and 0.45 eV (Pd).

Photocurrent maps of WSe_2 bimetallic device with different drain voltages

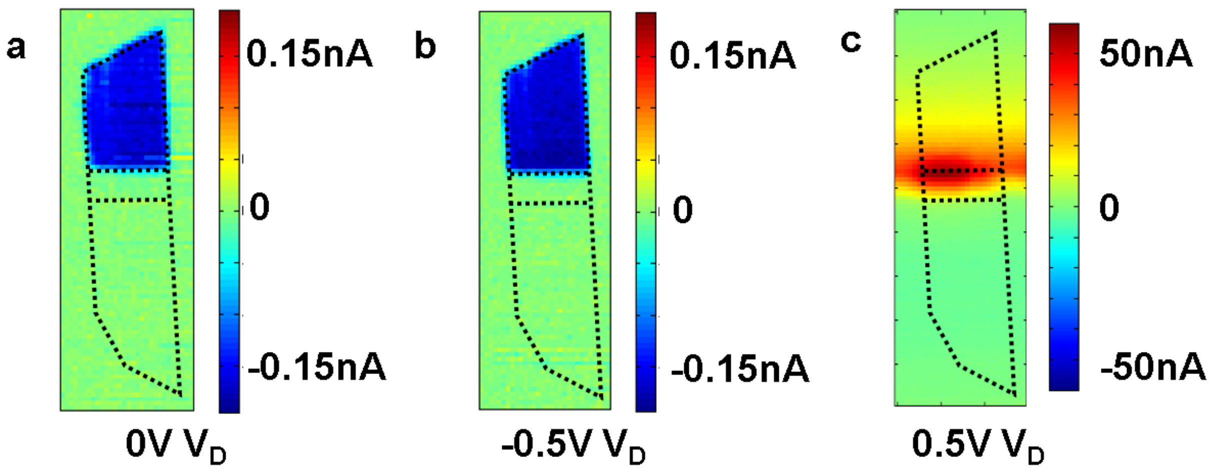

Figure S4. Photocurrent map at (a) V_D = 0 V, (b) V_D = -0.5 V, and (c) V_D = 0.5 V for the WSe_2 bimetallic device. With V_D = 0 V and V_D = -0.5 V, a small negative photocurrent from PV effect (gain ~ 0.3) was measured on the Ti electrode region. However, at V_D = 0.5 V, large positive photocurrent from PG effect (gain > 10) was measured in the channel region. The photocurrent measured appears to occur outside of the flake region, but this effect is due to the long decay time of the photo-response in this case, which is on the same order as the scan rate of the mapping system. The scanning speed of our measurement was 0.1 sec per measurement, and scanning direction was from the bottom to the top of the images. If the decay time of photo-response is larger than the scanning time per measurement, the photogenerated charges still survive and affect the measured current even after the laser spot moves to next position, which causes false photocurrent out of the flake. The large photocurrent with the large decay time in the channel region indicates the photocurrent is based on the PG mechanism.