Supporting Materials

Role of Metal Contacts in High-Performance Phototransistors Based on WSe_2 Monolayers

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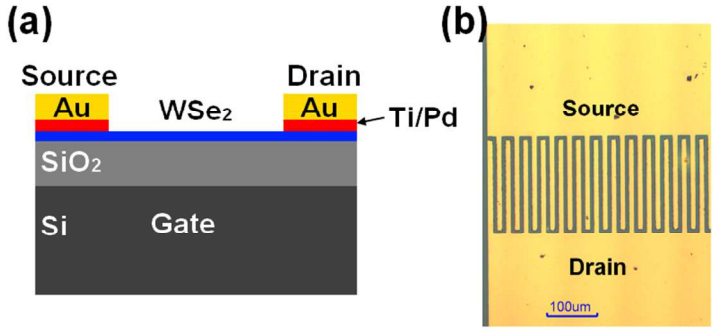

Figure S1. (a) Schematic diagram of the phototransistor device structure based on the a CVD WSe_2 monolayer. (b) Top view optical microscopy of the CVD monolayer WSe_2 photodetector. The interdigitated electrodes can substantially increase the metal–WSe_2 contact region, which shall lead to the enhancement in photocarrier generation.

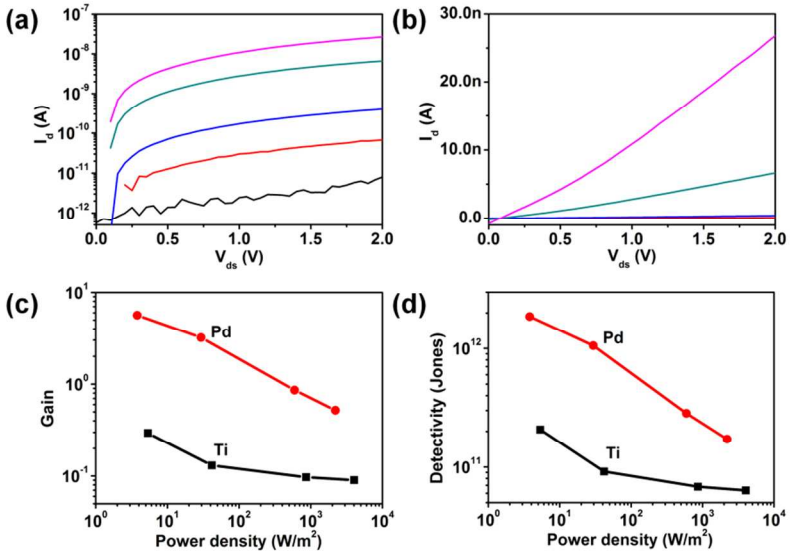

Figure S2. Photoresponse of the CVD monolayer WSe_2 phototransistor with Ti metal contacts. (a) and (b) I_d-V_{ds} characteristics of the phototransistor as a function of light intensity on a logarithmic and linear scale, respectively, at V_g=0V. From bottom to top, the curves were measured at the following intensities: in dark (black), 5.3W/m^2 (red), 41.9W/m^2 (blue), 863.4W/m^2 (dark cyan) and 0.4W/cm^2 (magenta). (c) and (d) The laser power dependence of the photo gain and special detectivity of the phototransistor in ambient air at V_{ds}=2V.

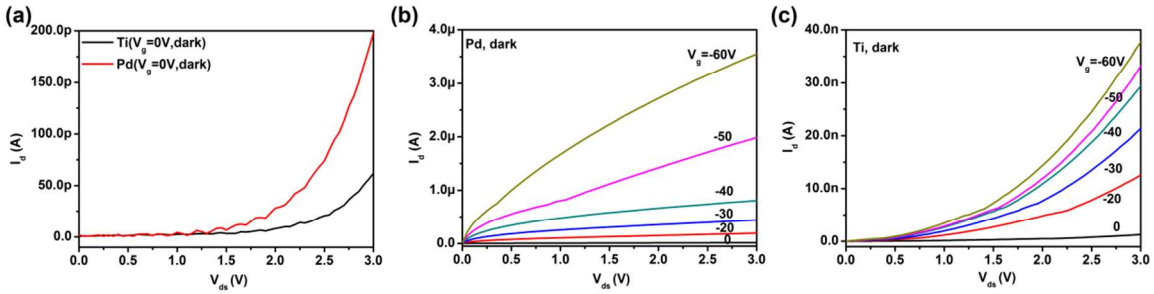

Figure S3. Schottky contacts for the Pd- and Ti-contacted monolayer WSe_2 phototransistors. (a) I_d-V_{ds} curves at V_g=0V in dark. (b) and (c) The I_d-V_{ds} curves for the Pd- and Ti-contacted devices at different negative gate voltages in dark. As shown in Figure S3a, I_d-V_{ds} curves for the CVD monolayer WSe_2 devices with Pd and Ti contacts are nonlinear, indicating that there are Schottky barriers between electrodes and WSe_2 channels for both metal contacted devices, and the Schottky barrier height of the Ti-contacted device is higher than that of the Pd-contacted device for the smaller threshold drain voltage and higher drain current at the same V_{ds} and V_g. As shown in Figures 2a and 4a in the text, the two kinds of devices are in OFF states at V_g=0V in ambient air. This is reasonable with nonlinear transfer curves and Schottky barriers at Vg=0V. However, the I_d-V_{ds} curves of Pd-contacted devices became linear and saturated at higher negative gate voltages (Figure S3b), indicating that the Fermi level has moved to the valence band forming ohmic-like contacts between electrodes and WSe_2 channels. In contrast, the I_d-V_{ds} curves of Ti-contacted devices remained upward nonlinear (Figure S3c), indicating that the Schottky barrier persisted even at high negative gate voltages.

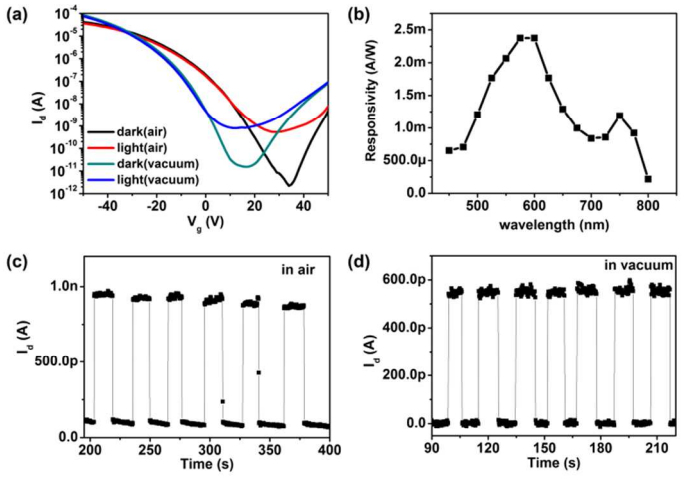

Figure S4. The photoresponse properties of a typical Ti-contacted WSe_2 phototransistor half a year later. (a) The electrical and optical transport properties of the photodetector in high vacuum (3.56×10^{-6}mbarr) and ambient air at the 650nm laser power density

46.5W/m^2, V_{ds}=2V. (b) In high vacuum, the wavelength dependence of the responsivity for the phototransistor in the OFF state at V_{ds}=2V. (c) and (d) The photoswitching behaviors in ambient air and high vacuum, respectively, at the laser power density 46.5W/m^2, V_{ds}=2V, and V_g=0V. Even half a year later after fabrication of the CVD WSe_2 phototransistors, the mobility of a typical device in high vacuum was ~1.5 cm^2/Vs, the current ON/OFF ratio was ~10^7, the transconductance was ~5.4μS, and the subthreshold swing was ~193mV/dec for the bottom gate structure. When exposed the device from high vacuum to ambient air, the performance decayed a little. Compared with the fresh samples(Figure 2 in the text), the electrical properties of the CVD WSe_2 phototransistors were quite stable. From the Figure S4b, we can find that the phototransistor still exhibited good wavelength selectivity. However, the responsivity in the OFF state decreased by about two orders of magnitude(compared with the Figure 6(a) in the text). Impressively, the response speed of the Ti-contacted devices still presented high, which was less than 50ms.