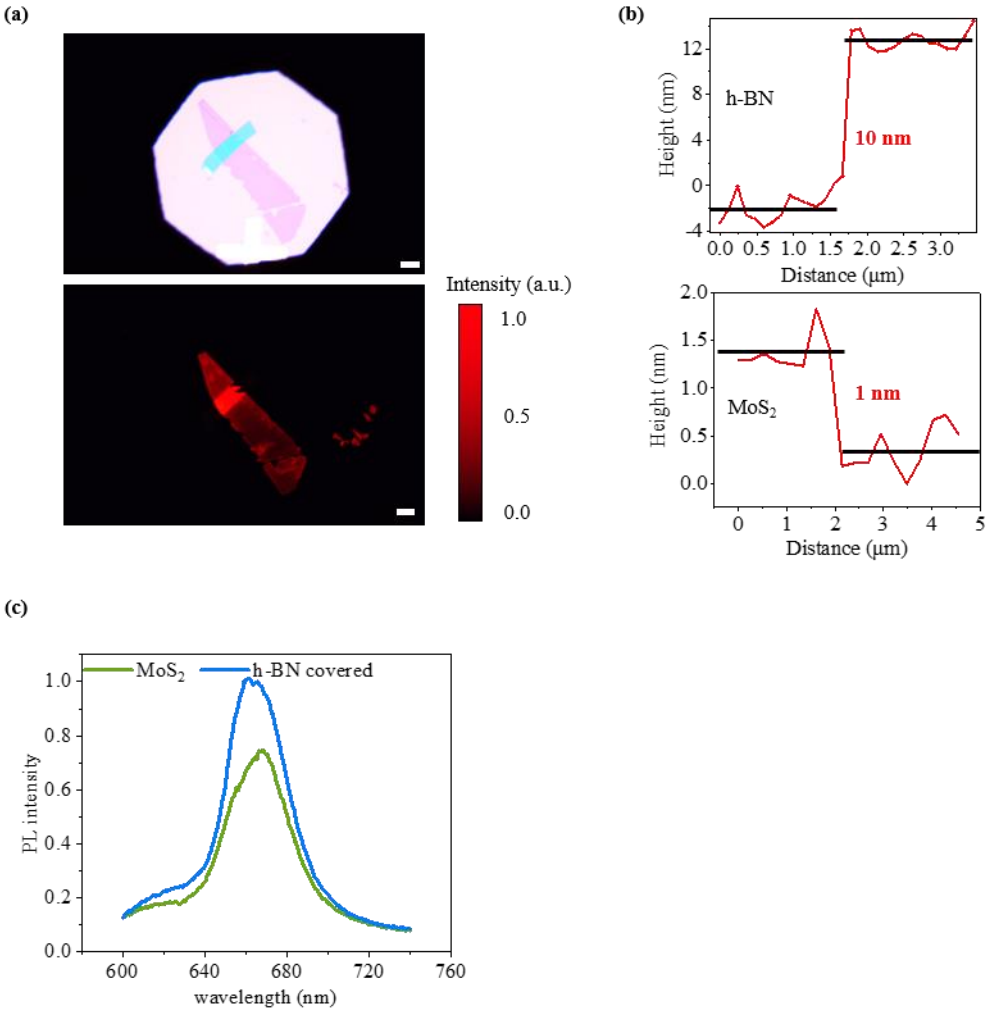
Supplementary Information for Interface Engineering of Ferroelectric-Gated MoS_2 Phototransistor

Shuaiqin WU,[1,2] Xudong WANG,[1†] Wei JIANG,[1,2] Luqi TU,[1,2] Yan CHEN,[1] Jingjing LIU,[1] Tie LIN, [1†] Hong SHEN,[1] Jun GE,[1] Weida HU,[1] Xiangjian MENG,[1] Jianlu WANG,[1,3] Junhao CHU,[1]



Figures S1 (Color online) Structure and characterization of few-layer MoS_2 and h-BN. (a) Optical microscope image and fluorescent image of the exfoliated monolayer MoS_2 sample. The purple flake is the MoS_2 and blue flake is h-BN. Sale bar, 10 μm. (b) The height of MoS_2 and h-BN is 1 nm and 10 nm respectively, measured by atomic force microscope (AFM). (c) Photoluminescence spectra observed in MoS_2 and MoS_2 covered with BN. The PL intensity in MoS_2 covered with h-BN is higher than that in MoS_2.

MoS_2 is a mature material in the two-dimensional transition metal dichalcogenides. As shown in Figure S 1(a), we prepare a monolayer MoS_2 sample [1]. It is reported to have low photoluminescence quantum yield at room temperature for its considerable defect density [2]. We use h-BN to enhance the photoluminescence of MoS_2 and presumably, h-BN can protect MoS_2 from ambient air and decrease the traps in the MoS_2 surface.

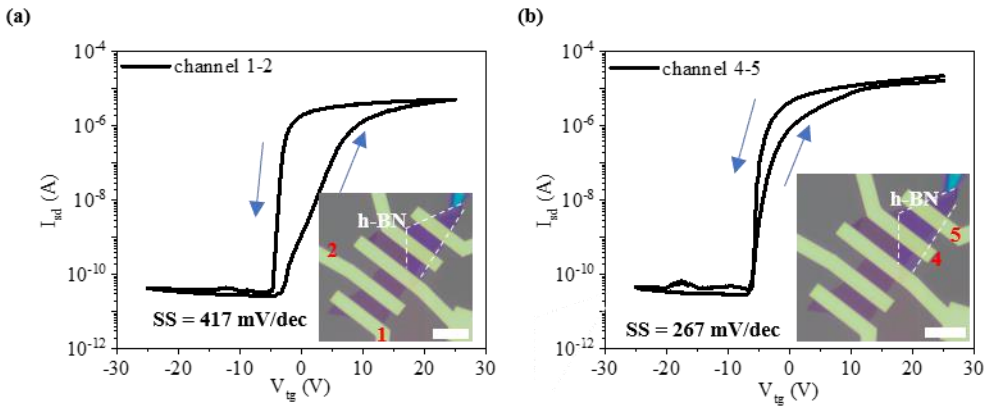


Figure S2 (Color online) Electrical property of MoS_2 device. (a) and (b) Transfer characteristic with V_{tg} ranging from -30 V to 30 V while V_{sd} = 1 V. The inset is the optical image of the device. Scale bar, 10 μm. The forward subthreshold swing ($SS_{forward}$) is 2500 mV/dec, and $SS_{reverse}$ is 427 mV/dec in (a) and belongs to the MoS_2 channel without h-BN and (b) is the MoS_2 channel with h-BN covered with $SS_{forward}$ is 667 mV/dec, and $SS_{reverse}$ is 267 mV/dec. Sale bar, 10 μm.

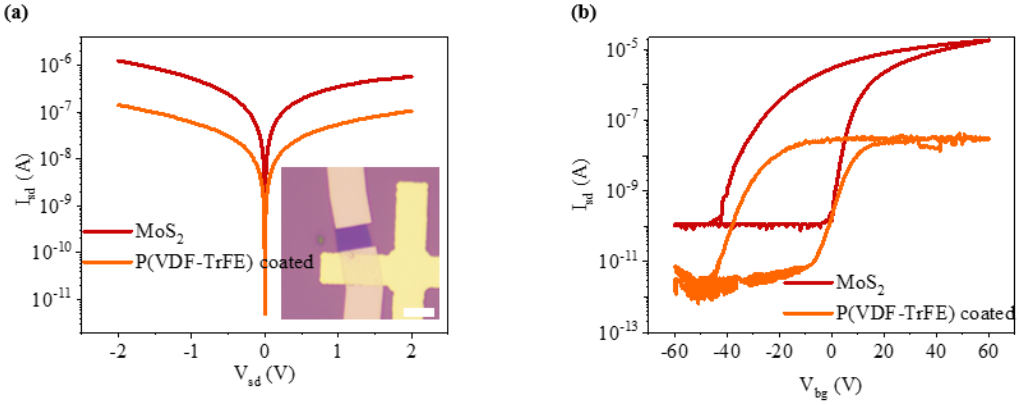


Figure S3 (Color online) Electric characteristic of MoS_2 device. (a) The I_{sd}-V_{sd} curves were measured before and after P(VDF-TrFE) coating, respectively. The inset is the optical image of the device measured in this work. Sale bar, 10 μm. (b) Transfer curves of MoS_2 transistor gated by SiO_2 before and after P(VDF-TrFE) coating, respectively.

The p-doping phenomenon is not rare which were observed on WSe_2, black phosphorus and $MoTe_2$ with P(VDF-TrFE) or P(VDF-TrFE-CFE) as the gate dielectric [2-4]. From Figure S 3(a) and (b), we also observed this phenomenon in the MoS_2 device. According to the previous reports, it is attributed to the negative dipole in P(VDF-TrFE) or P(VDF-TrFE-CFE).

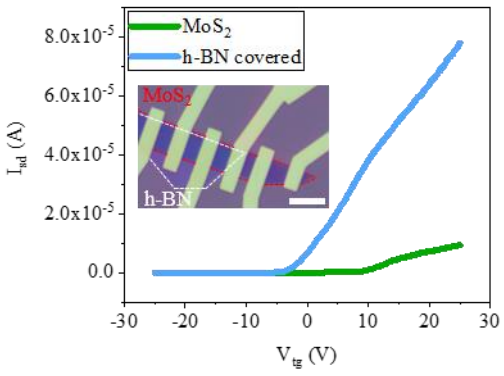


Figure S4 (Color online) Transfer curve of MoS_2 devices with and without h-BN in linear coordinates. Scale bar, 10 μm.

References

1 Radisavljevic B, Radenovic A, Brivio J, et al. Single-layer MoS_2 transistors. Nat Nanotech, 2011, 6: 147-150

2 Amani M, Lien D H, Kiriya D, et al. Near-unity photoluminescence quantum yield in MoS_2. Science, 2015, 350: 1065-1068

3 Yin L, Wang Z X, Wang F, et al. Ferroelectric-induced carrier modulation for ambipolar transition metal dichalcogenide transistors. Appl Phys Lett, 2017, 110: 123106

4 Lee Y T, Kwon H, Kim J S, et al. Nonvolatile ferroelectric memory circuit using black phosphorus nanosheet-based field-effect transistors with P (VDF-TrFE) polymer. ACS Nano, 2015, 9: 10394-10401