Substantial and stable magnetoresistance and spin conductance in phosphorene-based spintronic devices with Co electrodes[†]

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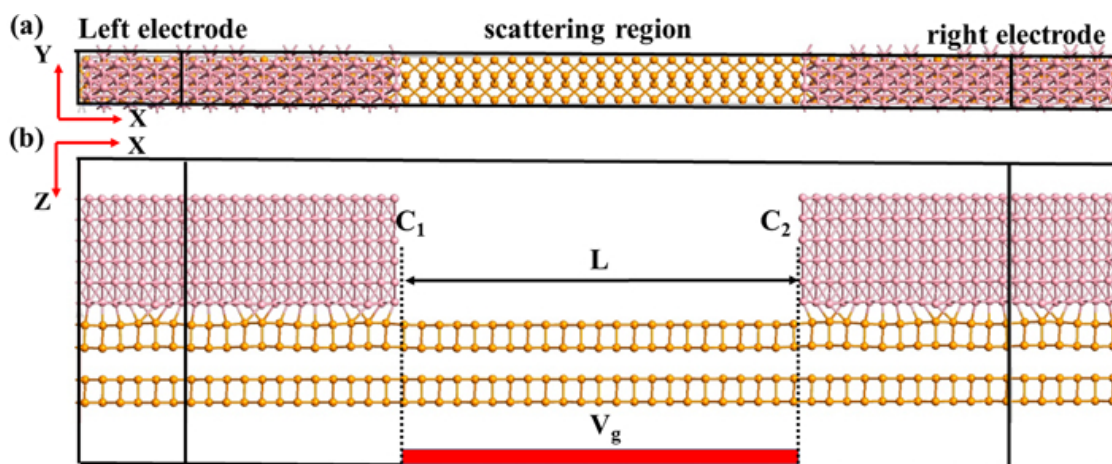*Corresponding Author: E-mail: haidi@hfut.edu.cn, zjli@hfut.edu.cn

Figure S1 (a) Top and (b) side view of the structure of BL phosphorene device with Co(111) electrodes. The black solid rectangles on side of the left and right represent the left and right electrodes and black solid rectangle in the middle represents the scattering region. The length L of BL phosphorene is 4.0 nm in the central scattering region. The region of controlling by a gate voltage V_g is form C_1 to C_2. Yellow spheres denote P and and pink spheres denote Co atoms, respectively.
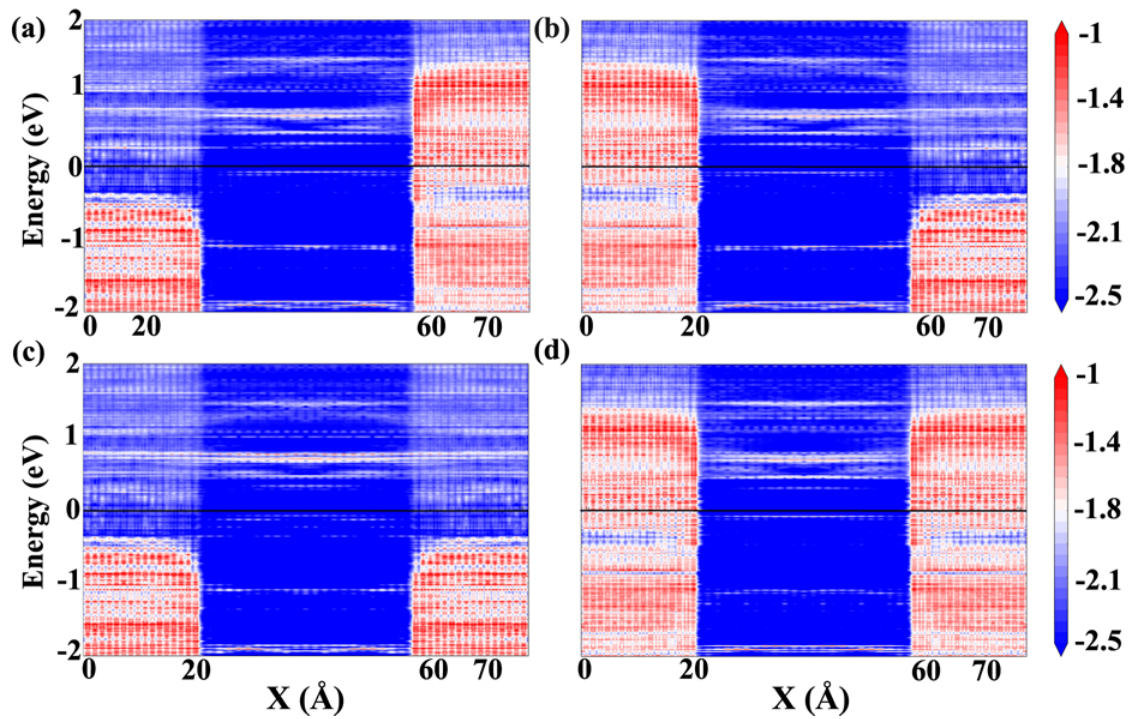
Figure S2 PLDOS (a) spin up and (b) spin down states in APC, (c) spin up and (d) spin down states in PC of BL phosphorene device, respectively. PLDOS is plotted on logarithmic scale.
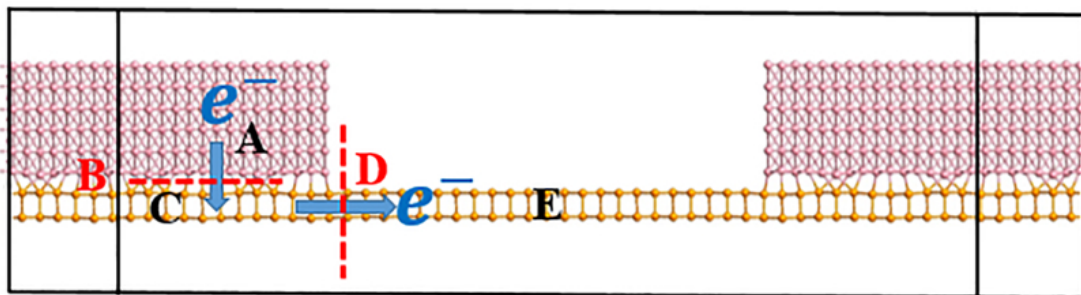

Figure S3 Schematic cross-sectional view of a ML phosphorene-based device (n-type). A, C, and E denote the three regions while B and D are the two interfaces separating them. Blue arrows show the pathway (A→B→C→D→E) of electron injection from contact metal (A) to the phosphorene channel (E).
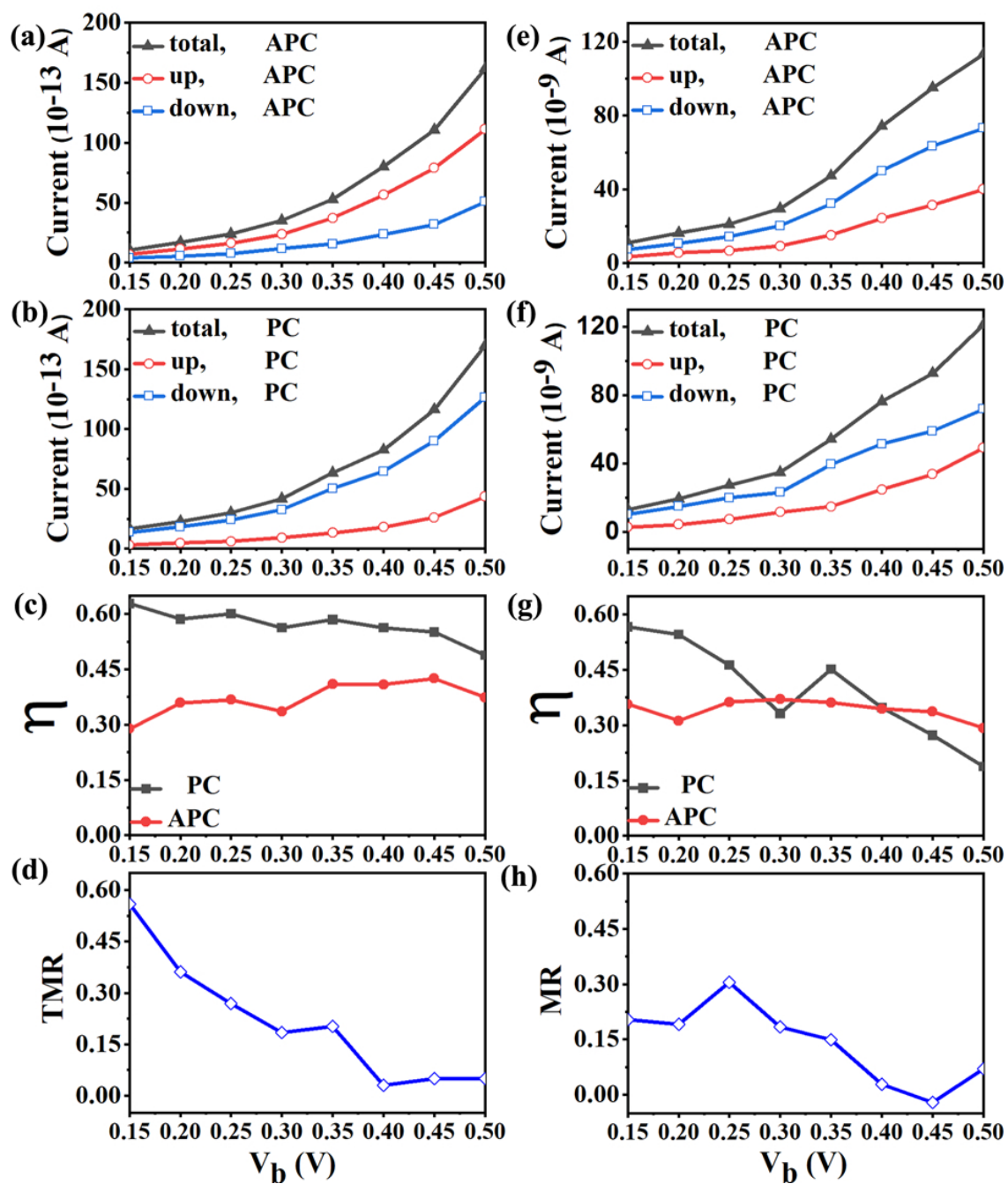
Figure S4 I-V curves for (a) APC and (b) PC; (c) SIE and (d) TMR versus bias voltage for ML phosphorene device. I-V curves for (e) APC and (f) PC; (g) SIE and (h) TMR versus bias voltage for BL phosphorene device.
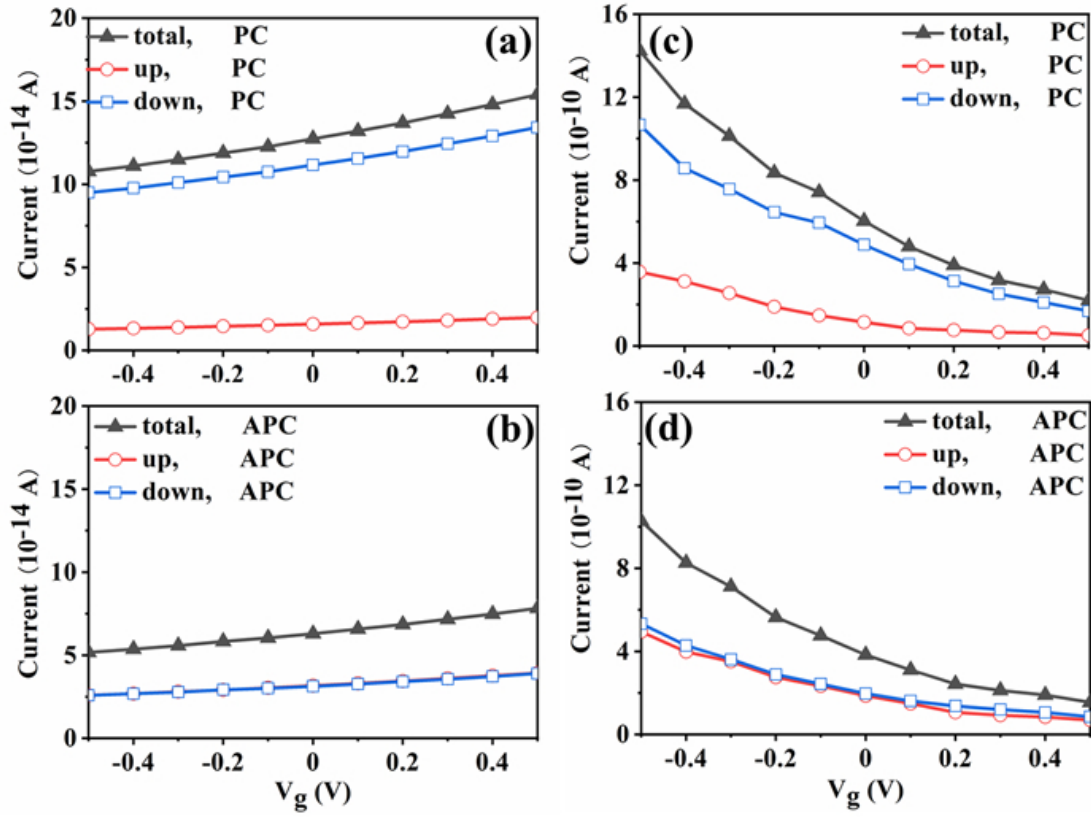
Figure S5 (a) and (b) the spin dependent current versus the gate voltage V_g (at the bias voltage of $0.01\,V$) for PC and APC of ML phosphorene device, respectively; (c) and (d) the spin dependent current versus the gate voltage V_g (at the bias voltage of $0.01\,V$) for PC and APC of BL phosphorene device, respectively.
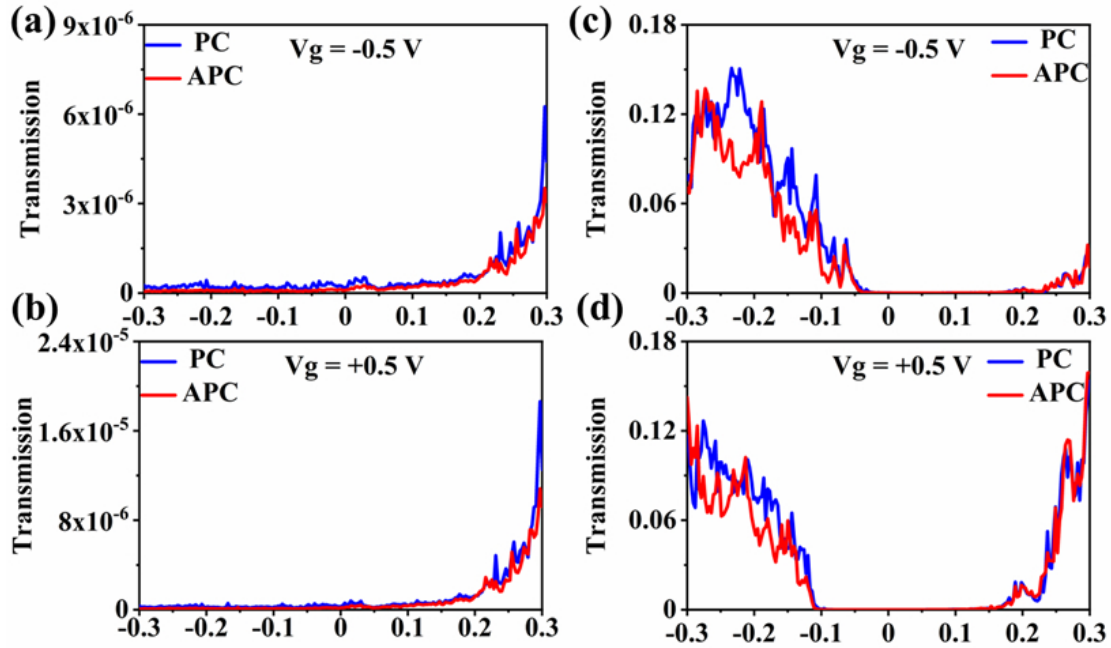

Figure S6 (a)-(b) for ML phosphorene device. Transmission coefficient versus electron energy at different gate voltages V_g : (a) $V_g = -0.5\,V$; (b) $0.5\,V$. (c)-(d) for BL phosphorene device. Transmission coefficient versus electron energy at different gate voltages V_g : (a) $V_g = -0.5\,V$; (b) $0.5\,V$.
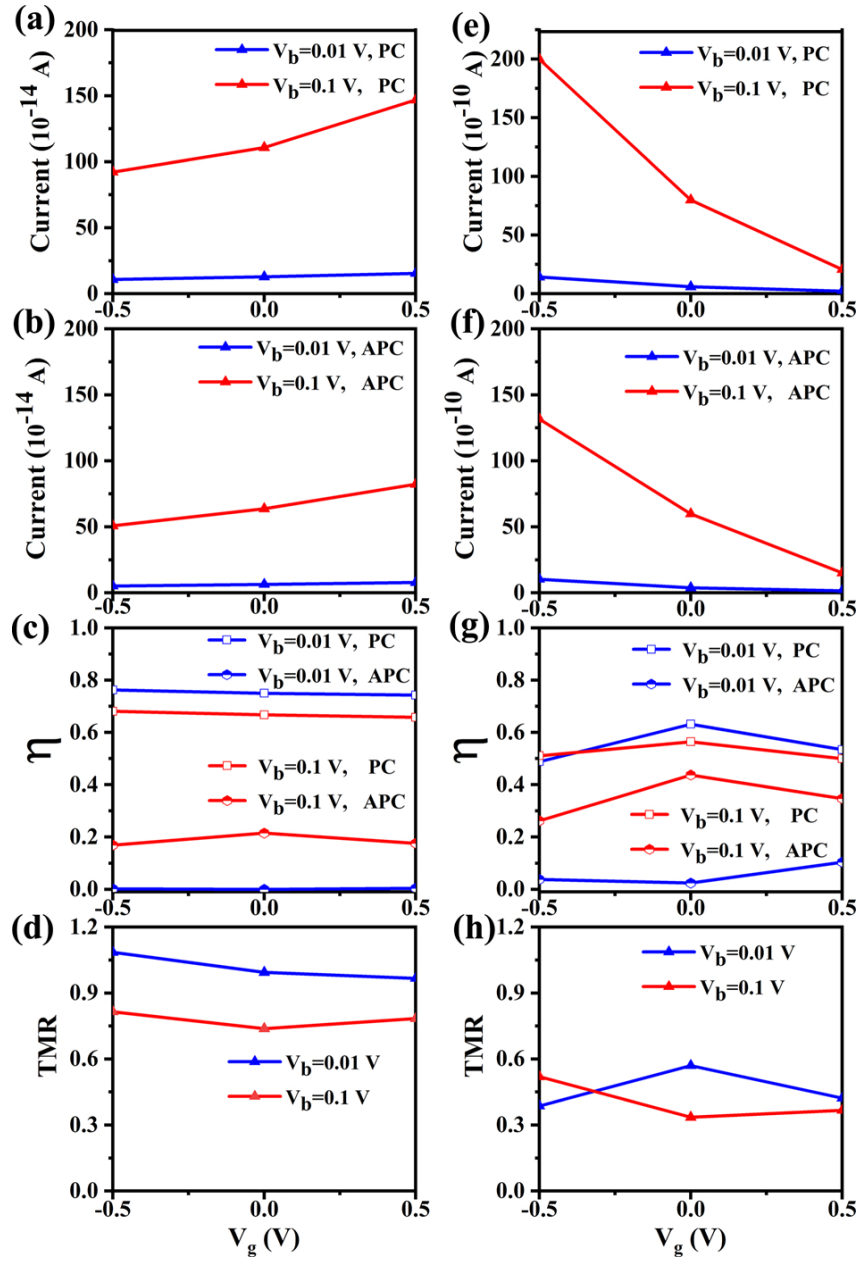
Figure S7 The spin-polarized current for (a) PC and (b) APC; (c) SIE and (d) TMR versus the gate voltage V_g (at the bias voltage of 0.01 V and 0.1 V) for ML phosphorene device, respectively. The spin-polarized current for (e) PC and (f) APC; (g) SIE and (h) TMR versus the gate voltage V_g (at the bias voltage of 0.01 V and 0.1 V) for BL phosphorene device, respectively.