Supporting information

Phosphorene nano-heterostructure based memristor with broadband response synaptic plasticity

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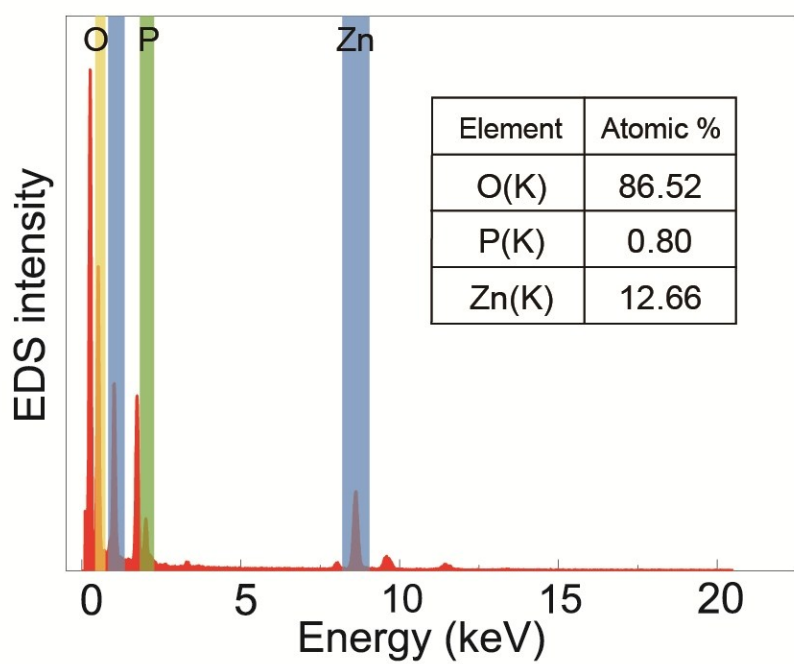
Figure S1. The typical EDS spectra of single ZP NP. The inset chart shows the atomic ratio of each element.
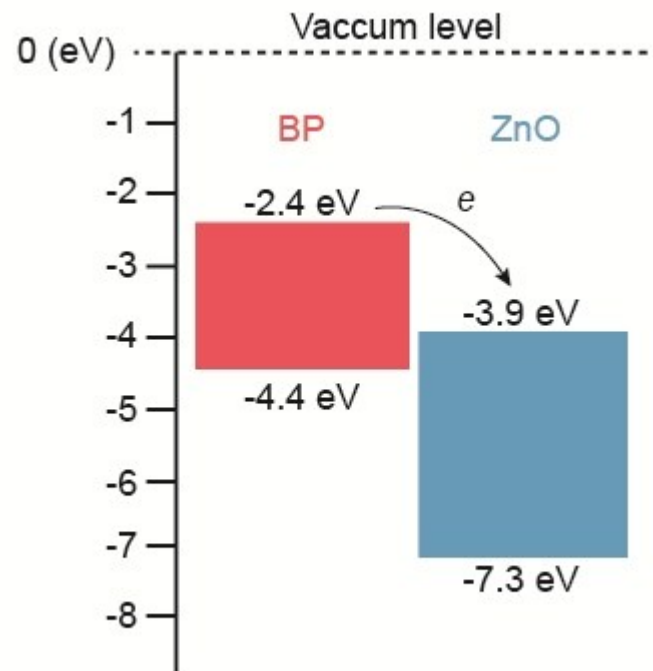
Figure S2. The type-II staggered band configuration of ZnO NPs and phosphorene
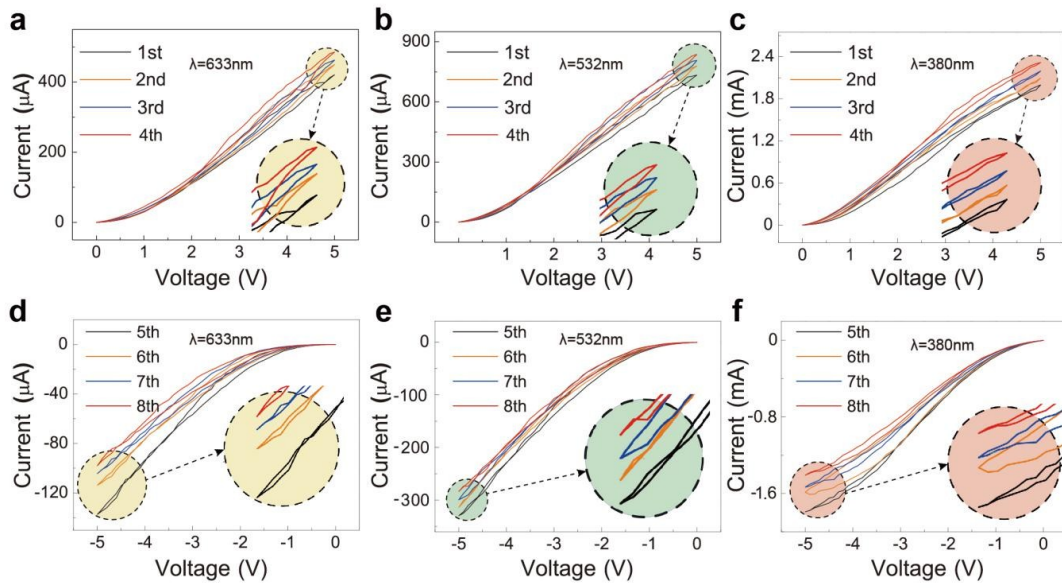(BP) QDs.

Figure S3. (a-c) I-V characteristics of the device showing gradual conductance enhancement by applying 4 consecutive positive sweeps after illumination with wavelength of 633 nm (a), 532 nm (b) and 380 nm (c). (d-f) I-V characteristics of the device showing gradual conductance depression by applying 4 consecutive negative sweeps after illumination with wavelength of 633 nm (d), 532 nm (e) and 380 nm (f).
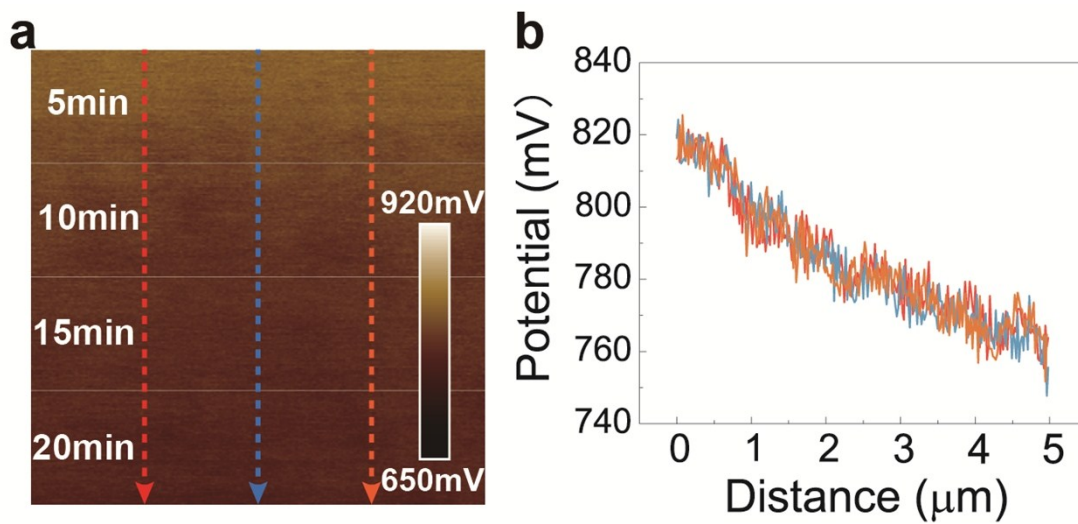
Figure S4. Potential change (a) after UV light illumination and (b) its dependence on the vertical distance recorded after 5, 10, 15 and 20 min.
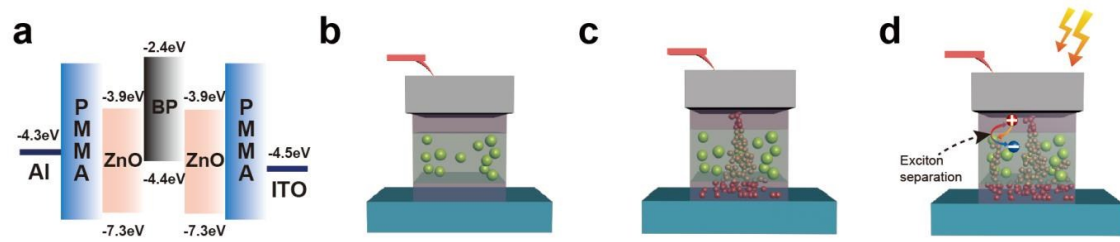
Figure S5. (a) Band alignment of device at initial state. (b-d) Illustration of device structure at the initial state (b), conduction filament forming process in the dark condition (c), and conduction filament forming under the illumination (d).
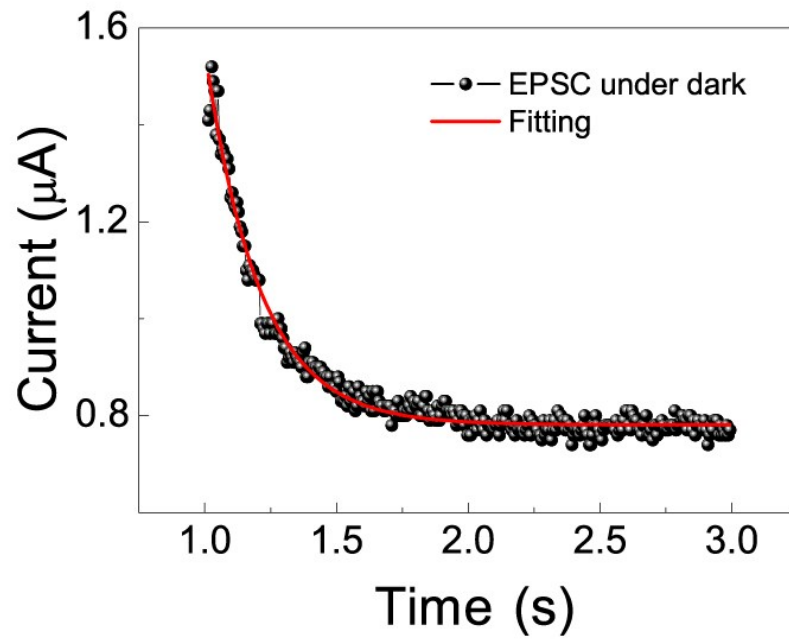
Figure S6. The exponential fitting data of EPSC in dark condition. I_0, A and τ corresponds to 7.81E-7 A, 1E-4 and 0.21 s, respectively.
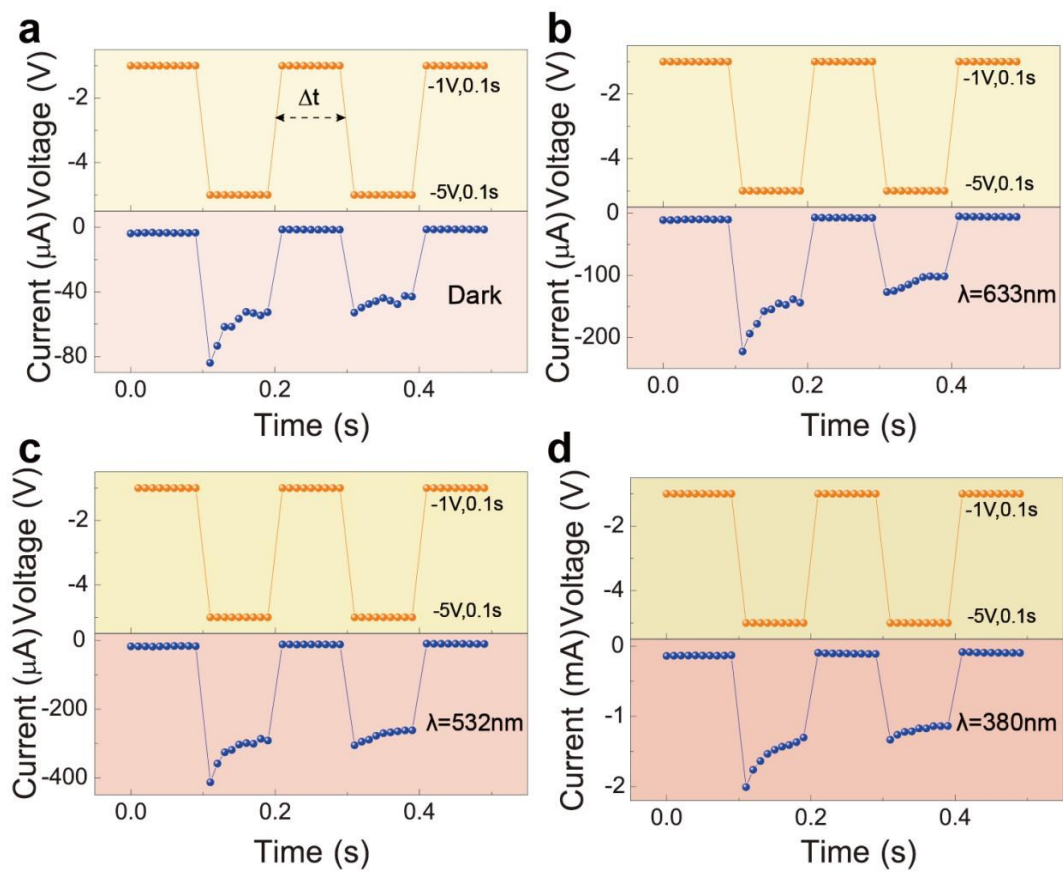
Figure S7. PPF (a) before and after illuminations with wavelength of (b) 633 nm, (c) 532 nm and (d) 380 nm by applying negative pulse trains.
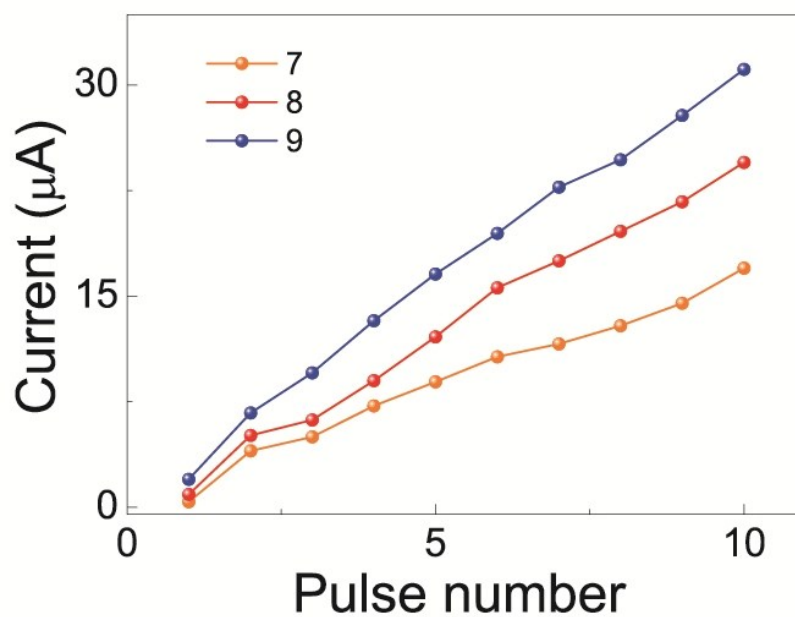
Figure S8. Conductance change of synaptic devices under 10 consecutive pulse trains with the base value of 1 V for 0.1 s and pulse amplitude of 5 V for 0.1 s. Different molar ratio of ZnO to phosphorene ranges from 7: 1 to 9: 1.
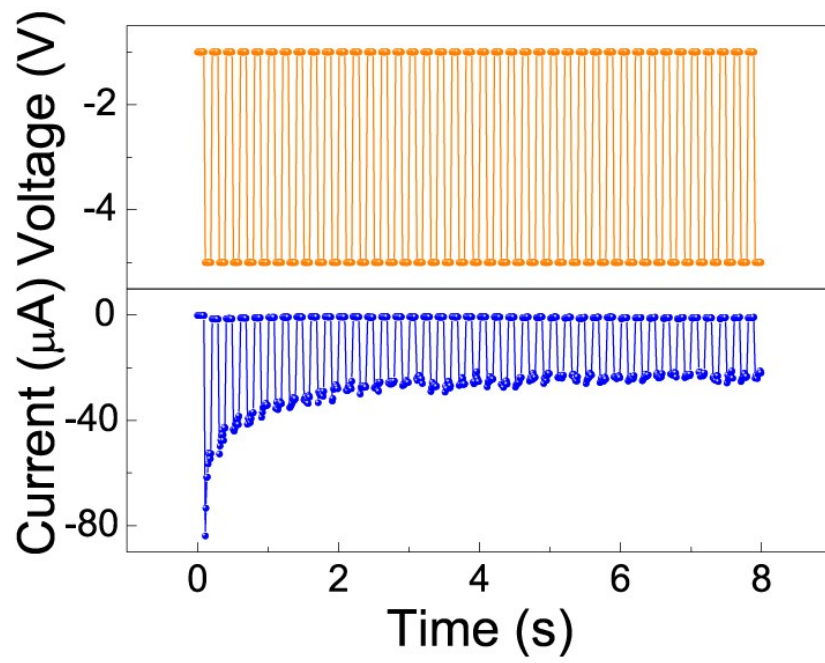
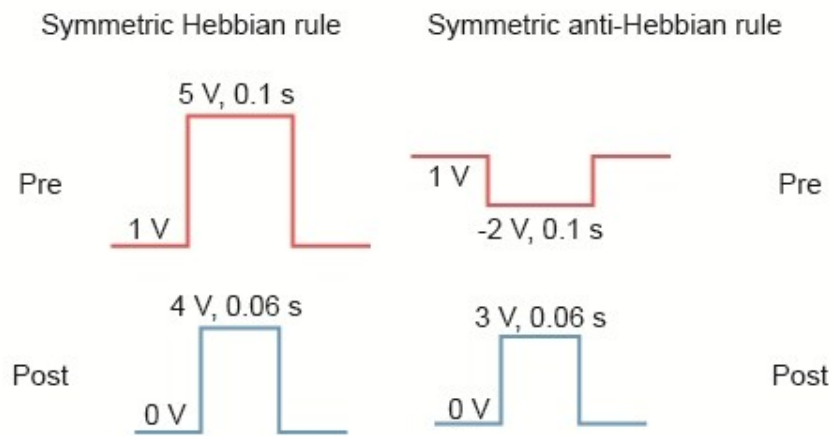**Figure S9.** Conductance depression by consecutive 40 pulse trains in negative directions.

Figure S10. Pre- and post-synaptic spikes utilized to implement Symmetric Hebbian rule and Symmetric anti-Hebbian rule.

N cycles	Interval 0.1s			Interval 0.01s		
	I_0	A	τ	I_0	A	τ
10	7.42E-7	1.83E-6	16.82	1.51E-6	9.05E-6	7.55
20	8.75E-7	2.21E-6	17.25	1.63E-6	1.11E-5	8.04
30	1.16E-6	4.37E-6	17.18	2.00E-6	1.17E-5	18.99
40	2.50E-6	1.53E-5	19.00	3.29E-6	1.19E-5	25.06
50	3.08E-6	1.54E-5	20.18	7.36E-6	1.31E-5	40.30
60	4.95E-6	2.39E-5	20.88	9.12E-6	1.41E-5	50.32

Table S1. Fitting results for Figure 4b-c.