Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supporting information

Artificial Synapses Based on Biopolymer Electrolyte Coupled SnO_2 Nanowire Transistors

Guangyang Gou[a,b], Jia Sun[a]*, Chuan Qian [a], Yinke He [a], Ling-an Kong [a], Yan Fu[b], Guozhang Dai[a,b]*, Junliang Yang [a], and Yongli Gao[a, c]

a. *Hunan Key Laboratory for Super Microstructure and Ultrafast Process, School of Physics and Electronics, Central South University, Changsha, Hunan 410083, P. R. China*

b. *Department of Applied Physics, School of Physics and Electronics, Central South University, Changsha 410083, Hunan, P. R. China*

c. *Department of Physics and Astronomy, University of Rochester, Rochester, NY 14627, USA*

* Corresponding authors: jiasun@csu.edu.cn (J. Sun)
gzdai2011@csu.edu.cn (G. Dai)

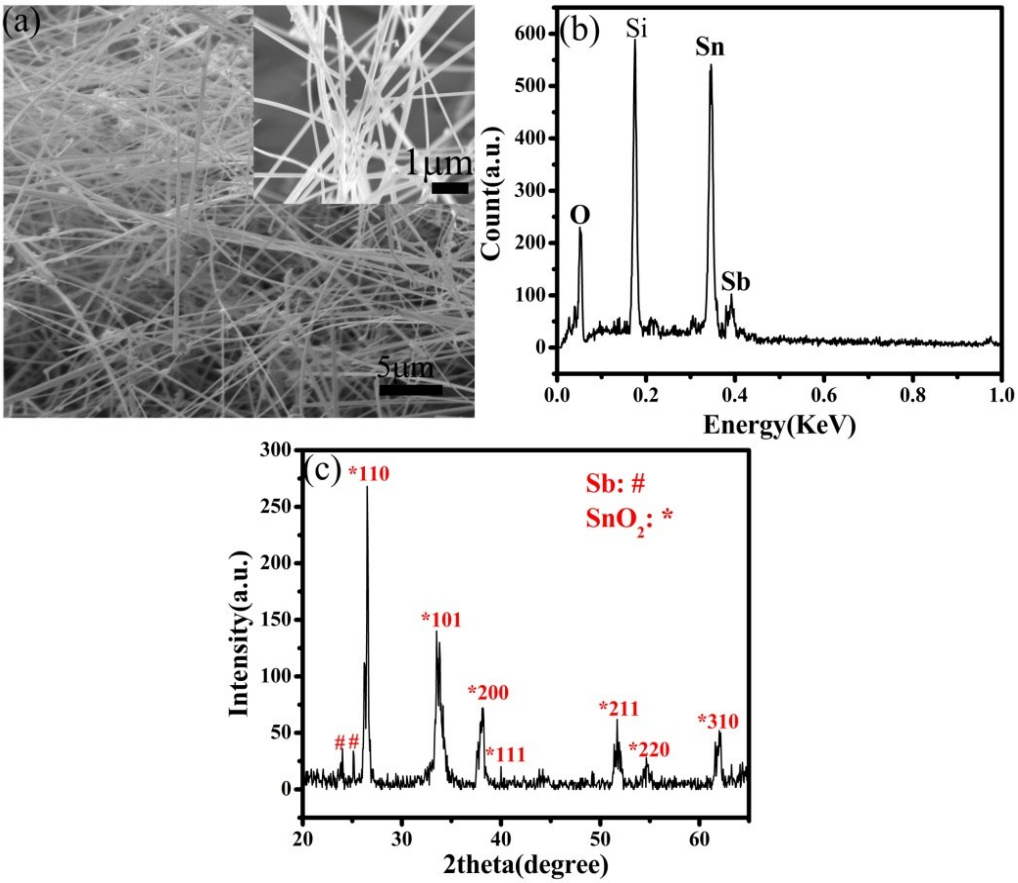

Figure S1: (a) SEM images of Sb-doped SnO_2 nanowires. (b) EDS spectrum of SnO_2 nanowires. (c) XRD result of the prepared products.

The typical SEM image in Figure S1(a) shows the as-grown Sb-doped SnO_2 nanowires deposited on the Si substrate by using Au nanocluster catalyst. As-synthesized nanowires are straight with the diameter in the range of 100 nm-400 nm and the lengths are typically greater up to several hundreds of micrometers. The EDS image of product is shown in Figure S1(b), which indicates that Sn, O, and Sb are present. Furthermore, the structure of as-deposited SnO_2 nanowires is determined by the XRD in Figure S1(c). All of the SnO_2 diffraction peak can be assigned to the tetragonal structure (a=4.7421Å, c=3.1901Å and JCPDS card is 77-449).

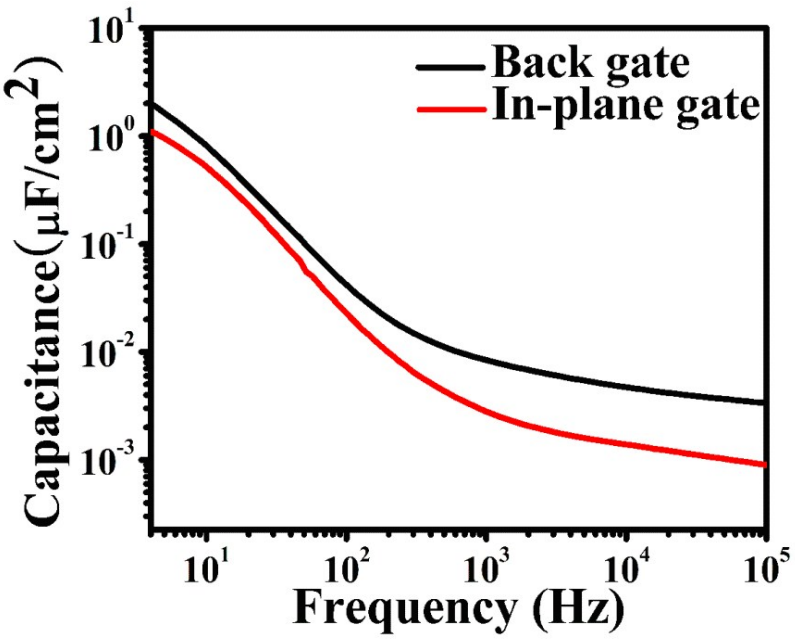

Figure S2: The specific capacitance-frequency curves of the chitosan-based proton conducting film measured with back gate and in-plane-gate structures.

Field-effect mobility of our devices in the saturation region can be estimated by $I_{ds}=(\mu C)/(2L^2)(V_{gs}-V_{th})^2$, where L= 7.0 μm is the channel length. The gate capacitance per unit length can be estimated as $C_g=C/L=2\pi\varepsilon_0\varepsilon_r/\ln(1+2L_D/d)$, where ε_r[1]is the dielectric constant of the chitosan film, ε_0 is the permittivity of free space, and d=300 nm is the diameter of the nanowire[2]. Debye length L_D is defined as the typical distance required for screening the surplus charge by the mobile carriers present in a material [3]. The mobility value of the in-plane gate and back-gate nanowire transistors is calculated to be 36.8 cm^2/Vs and 23.5 cm^2/Vs, respectively.

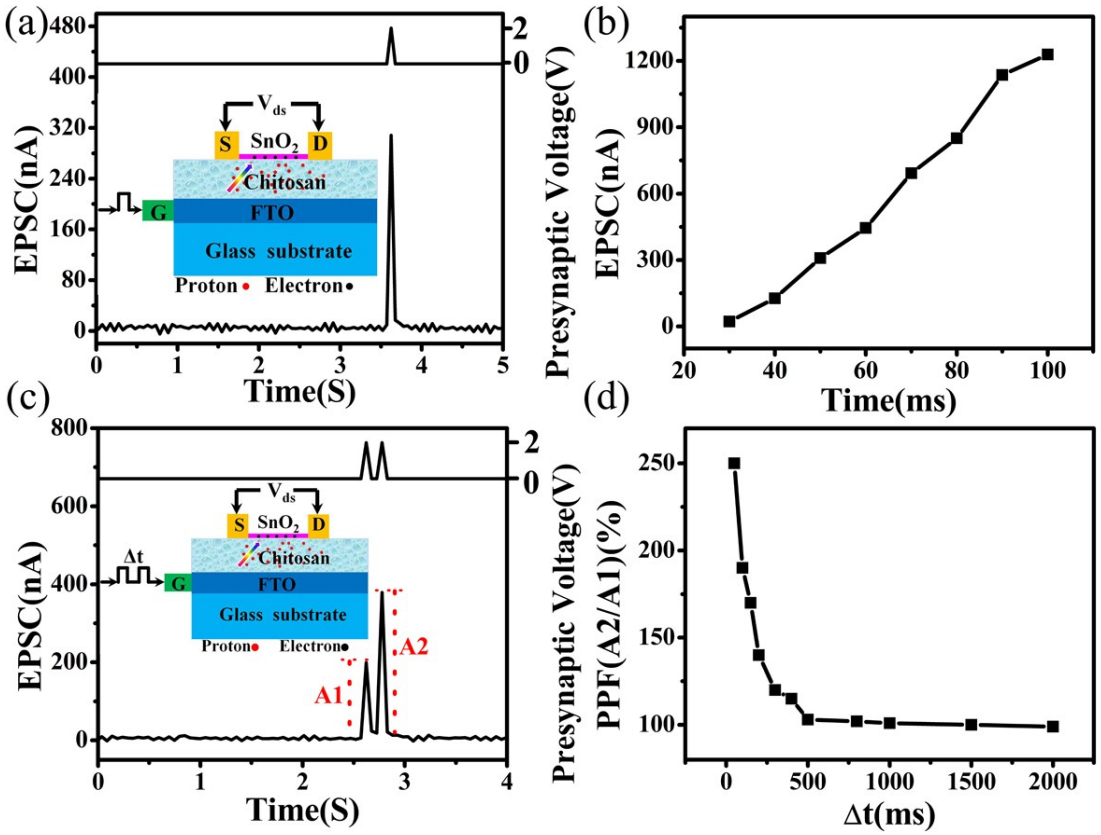

Figure S3: Spike applied on the back gate: (a) EPSC triggered by a presynaptic spike (2.0 V, 50 ms). EPSC is measured with a V_{ds} of 2.0 V. (b) Spike duration time-dependent EPSC, the amplitude of the spike is 2.0 V. (c) The EPSC triggered by a pair of presynaptic spikes with a time interval (Δt) = 100 ms. A1 and A2 are the amplitudes of the first and second EPSC, respectively. (d) PPF index (100%×A2/A1) plotted as a function of spike Δt.

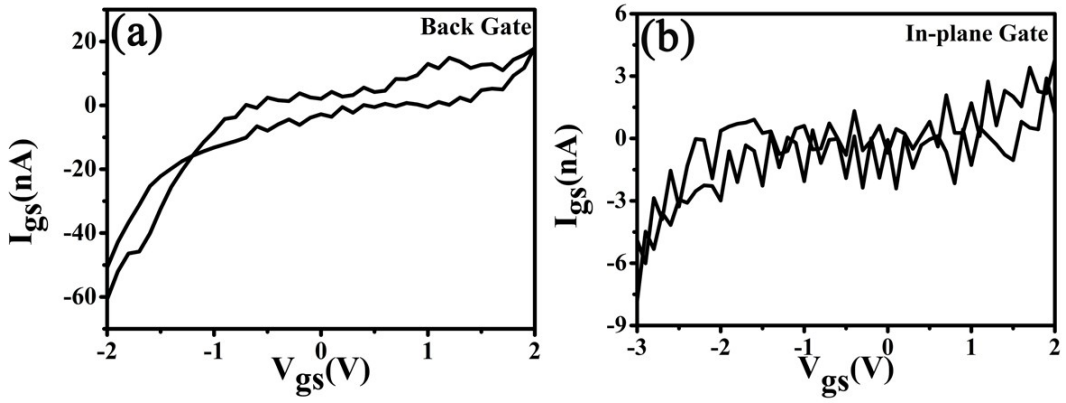

Figure S4: The leakage current of the chitosan film: (a) back-gated structure, (b) in-plane structure.

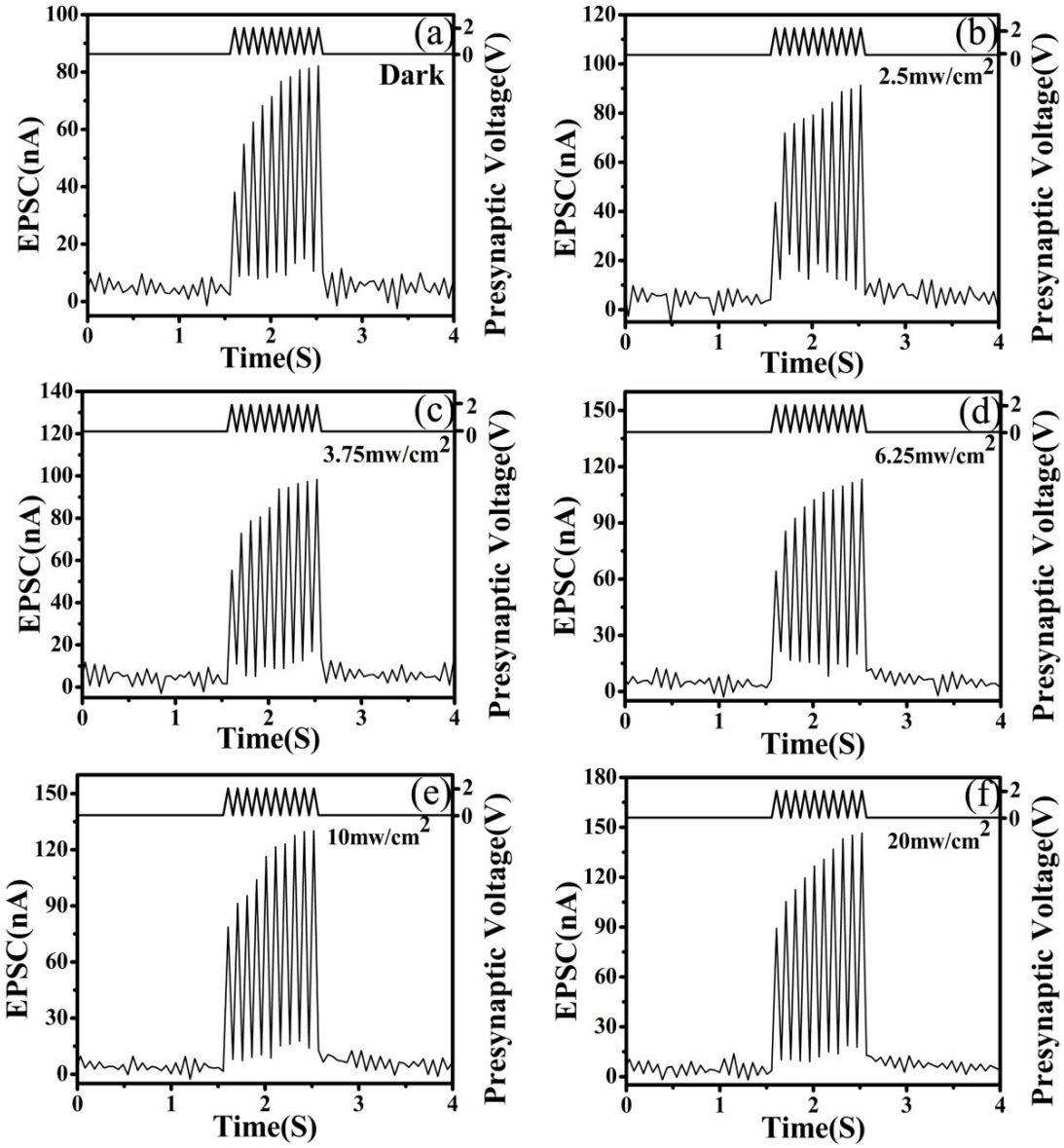

Figure S5: The EPSC recorded in response to the light intensity (365 nm): (a) dark, (b) 2.5 mW/cm^2, (c) 3.75 mW/cm^2, (d) 6.25 mW/cm^2, (e) 10 mW/cm^2, (f) 20 mW/cm^2.

References

[1] C. G. A. Lima, R. S. D. Oliveira, C. F. Wehmann. *Materials Chemistry & Physics*., **2006**, 99, 284-288.

[2] G. P. Siddons, D. Merchin, J. H. Back, J. K. Jeong and M. Shim, *Nano Lett*., **2004**, 4, 927-931.

[3] P. Debye, ***Chem. Rev***., 1936, 19, 171–182.