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

Bulk-Heterojunction Photocapacitors with High Open-circuit Voltage for Low Light Intensity Photostimulation of Neurons

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Fig. S1 Optical spectrum of blue LED at 20 mW.cm^{-2} with FWHM of 16.7 nm.

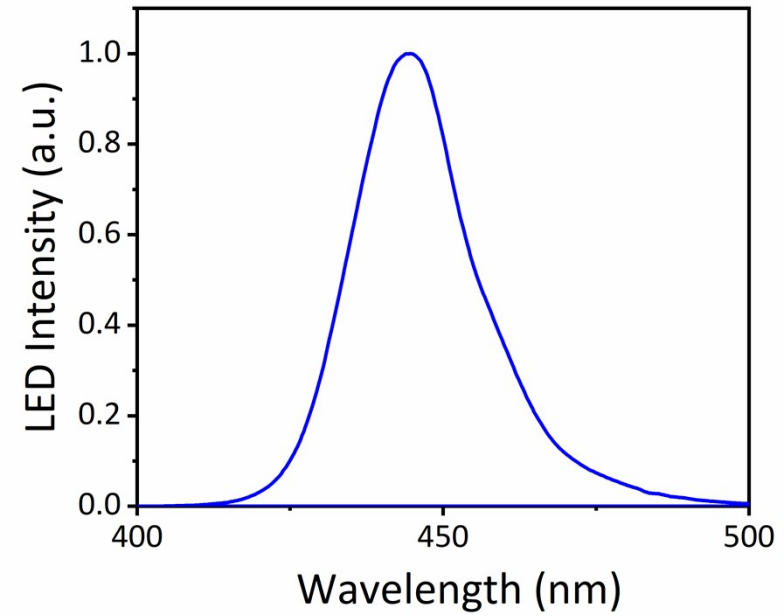


Fig. S2 The equivalent circuit model for fitting the Nyquist plot of biointerfaces in 3-electrode configuration. (a) Equivalent circuit with physical parameters of the BI-1 biointerface. (b) Equivalent circuit with physical parameters of the BI-2 biointerface.

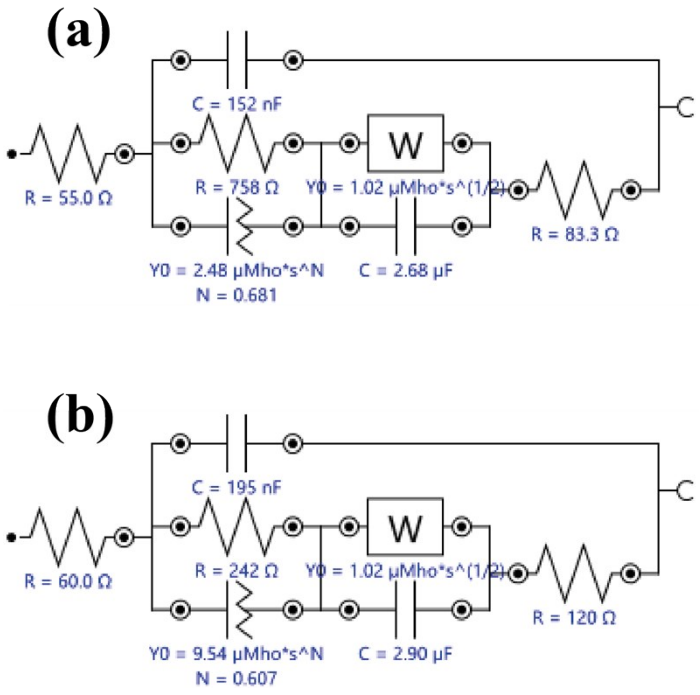


Fig. S3 Cytotoxicity assessment and immunofluorescence microscopy. (a) The effect of photoelectrodes on the metabolic activity of SH-SY5Y cells were assessed by MTT assay. DMSO samples corresponds to the cytotoxic control samples that are incubated with 10% DMSO. ITO was used positive control and % cell viability was calculated relative to ITO controls. Experiment was repeated for three times (n=3) with at least three technical replicates. Results are presented in a column graph plotting the mean with standard error of the mean. Unpaired two-tailed t-test was performed to determine level of significance; *p < 0.05 was considered as statistically significant, and nonsignificant differences are presented as "ns". (b) Morphology of the cells grown on photoelectrodes were visualized by fluorescence microscopy after DAPI staining and anti-beta III tubulin immunolabelling (scale bar = 100 µm).

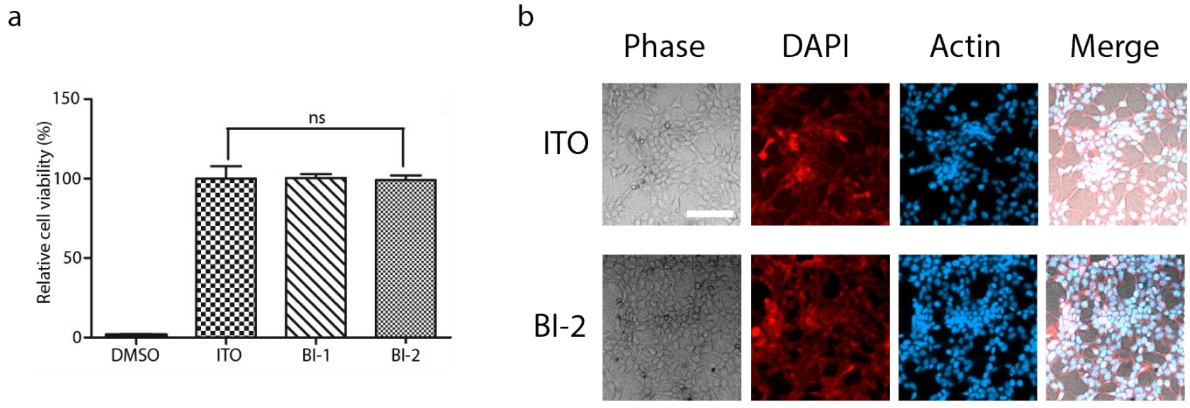


Fig. S4. The neural activity of the control group that consists of hippocampal cells cultured on a petri dish. It shows that there is no spontaneous activity as shown on the control substrate

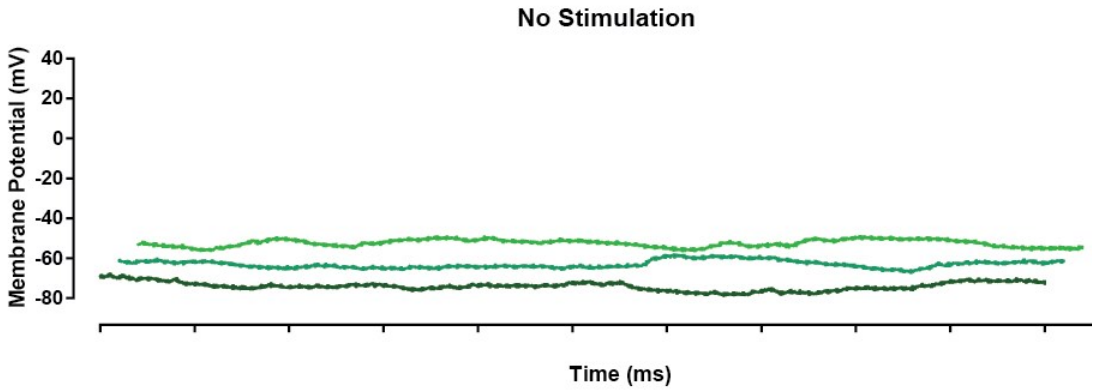


Fig. S5. Light evoked action potential response of primary hippocampal neuron during 1/0.1 ms light stimulation of the biointerface.

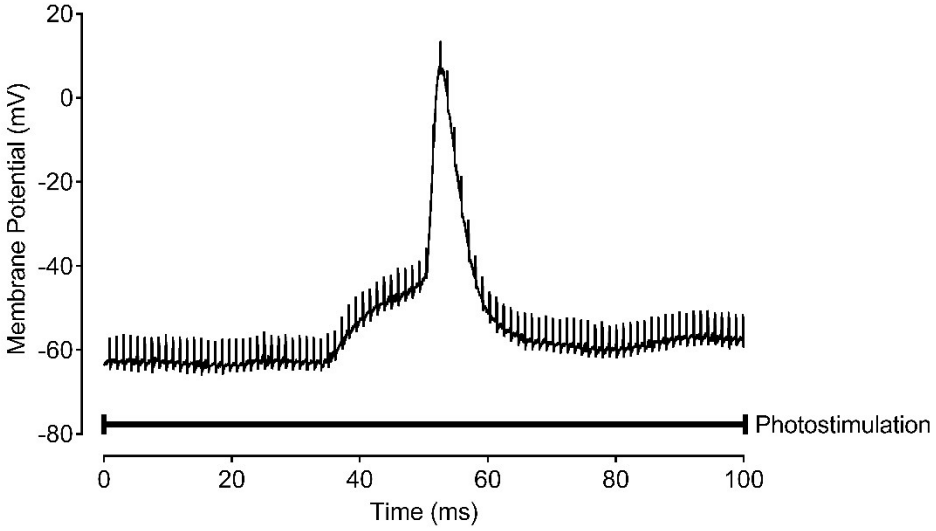
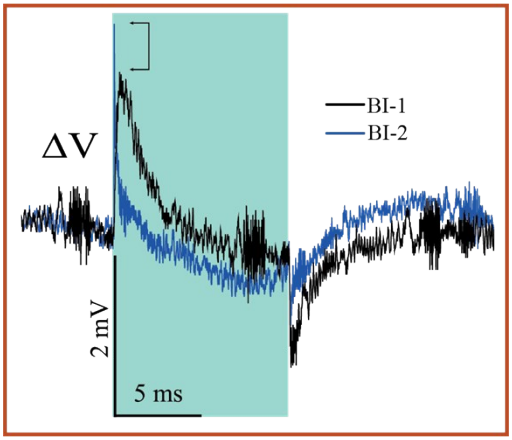


Fig. S6. Membrane potential variation of SH-SY5Y cells upon light illumination of 10 ms and 10 mW cm^{-2} light pulse. The plots for BI-1 and BI-2 biointerfaces are represented by black and blue lines, respectively.



We performed the electrophysiology experiment for both the electrodes using SH-SY5Y cells. An initial depolarization phase is observed both for BI-1 and BI-2 biointerfaces during the turning on the illumination. During the turn-off of the illumination the decrease of the potential in the semiconductor led to a hyperpolarization of membrane potential. In comparison with BI-1, BI-2 having higher open-circuit voltage generated a stronger depolarization of 0.7 mV of cell membrane with faster switching time. It suggests that BI-2 biointerface has better photostimulation than BI-1, which is in-line with the higher and faster photocurrent response.

Appendix-1: Thermal Effect at Neuron Surface due to Light Illumination

Here we determine the maximum temperature change that can be induced by the biointerface.

For water;

$$d_q(rev,p) = mC_p dT \quad (1)$$

Where, d_q is related to light energy, C_p is the molar heat capacity of water, m is the molar amount of water.

Temperature change of dT can be calculated from the equation (1).

We use the integral form of the equation and apply experimental parameters as follows

$$\int_0^q dq(rev,p) = mC_p \int_{295K}^{T} dT \quad (2)$$

Considering water heat capacity as C_p=75.291 $JK^{-1}mol^{-1}$:

$$q = mC_p \Delta T \quad (3)$$

We can calculate the thermal energy (q) because of light illumination of 10 $mW.cm^{-2}$ (if all the light energy is converted to heat):

$$q = I \times t = 10ms \times 20mW = 2 \times 10^{-4} J \quad (4)$$

From equations (3) and (4) we obtain the temperature change:

$$2 \times 10^{-4} J = (0.0332g / 18g / mol) \times 75.291 JK^{-1} mol^{-1} \Delta T \quad (5)$$

$$\Delta T = 0.0007^{0} C$$

The light induced temperature rise should be below 1^{o}C (physiological range) as per ocular safety regulation. Therefore, the thermal change of 3-order less than the physiological range is not responsible for the photostimulation of the cells.