Supporting Information

Liquid-solid Dual-gate Organic Transistors with Tunable Threshold Voltage for Cell Sensing

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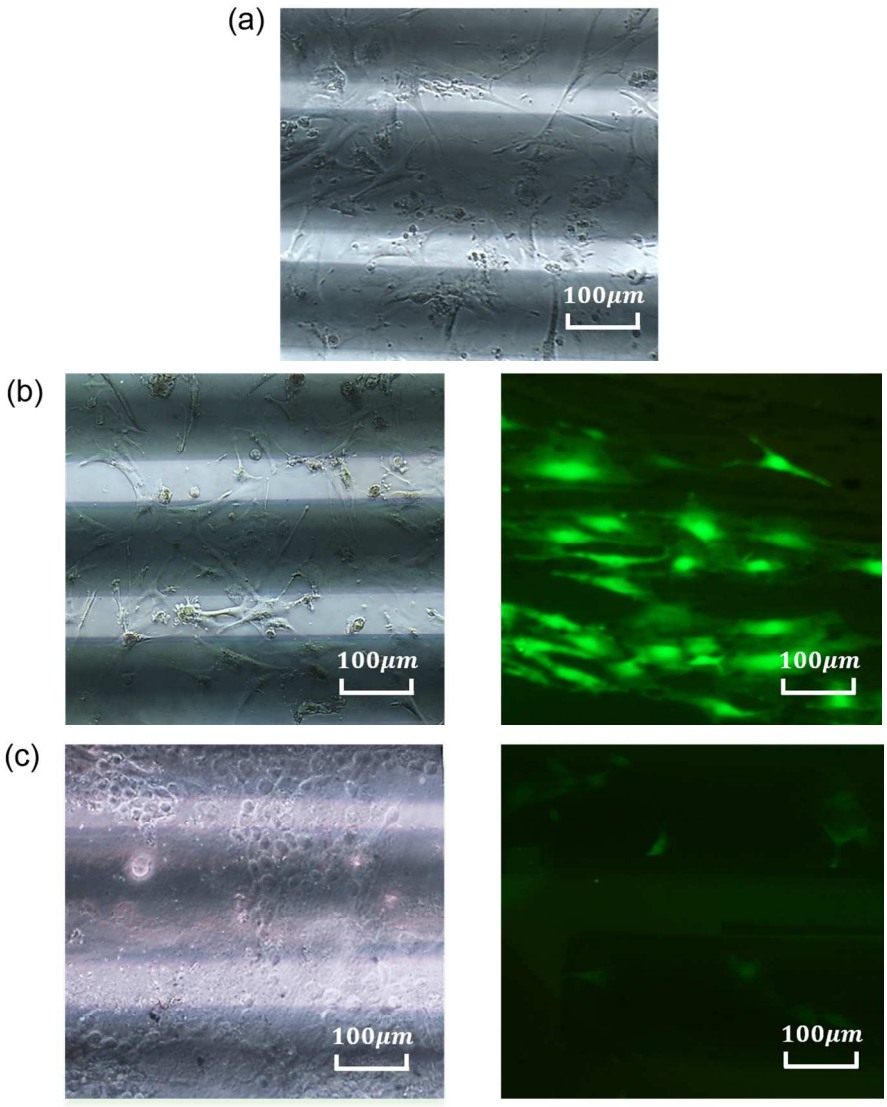

Figure S1. (a) Optical image of hMSCs before application of a gate voltage on DPP-DTT cell-sensor; (b) optical (left) and fluorescence (right) images of hMSCs after applying −0.3 V gate voltage for 5 minutes; (c) optical (left) and fluorescence (right) images of hMSCs after applying −0.35 V gate voltage for 5 minutes. Note that the optical and fluorescence images were not taken on the same device areas, but the shown cell morphologies were representative for the entire device.

Cell staining process for fluorescence imaging: After 5 minutes of −0.3 V/−0.35 V bias stress, the devices were incubated with 4 μM Calcein AM (Thermo Fisher Scientific, Invitrogen,

Waltham, Massachusetts, USA) in a basal growth medium at 37°C, 0.5% CO_2 for 30 minutes. Then the Calcein AM containing growth medium was subtracted and the devices were rinsed with PBS for twice. Cell viability was determined by analyzing the positive stained fluorescent cells in the images taken with a fluorescence microscope. Only the live cells could be positively stained, while dead cells have no fluorescence after operation.

After cell seeding, the hMSCs spread very well on the DPP-DTT film. However, when a −0.35 V gate voltage was applied on the DPP-DTT EGOFET for 5 minutes, the hMSCs turned into round and small morphologies and the fluorescence image indicates the fatal effect of high voltage to the cells (Figure S1c). On the other hand, the hMSCs can survive under −0.3 V top gate voltage as shown in Figure S1b. We thus set the cell-friendly voltage range to $<$0.3 V (absolute value) in this study.

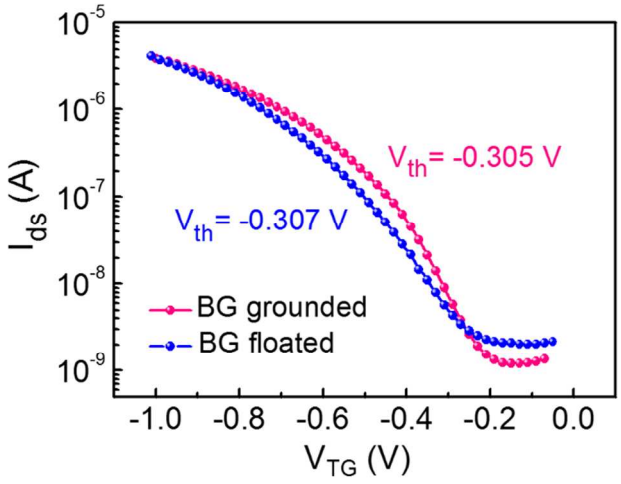

Figure S2. Comparison of transfer characteristics of the top-gate EGOFET with the bottom gate connected in a floated mode and grounded mode.

The top-gate transistor exhibits similar threshold voltage (grounded-bottom gate: −0.305 V; floated-bottom gate: −0.307 V) and mobility (grounded-bottom gate: 0.023 $cm^2V^{-1}s^{-1}$; floated-bottom gate: 0.022 $cm^2V^{-1}s^{-1}$) in these two test modes.

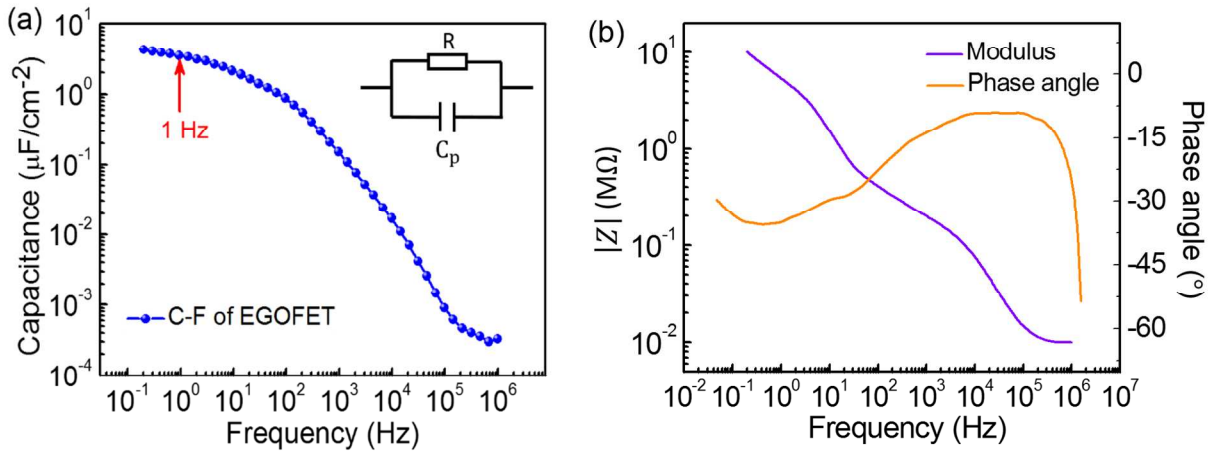

Figure S3. (a) Capacitance-frequency (C-F) relation of the EGOFET. Inset shows the fitting model to obtain the capacitance values. (b) The coresponding modulus and phase angles as a function of the frequency.

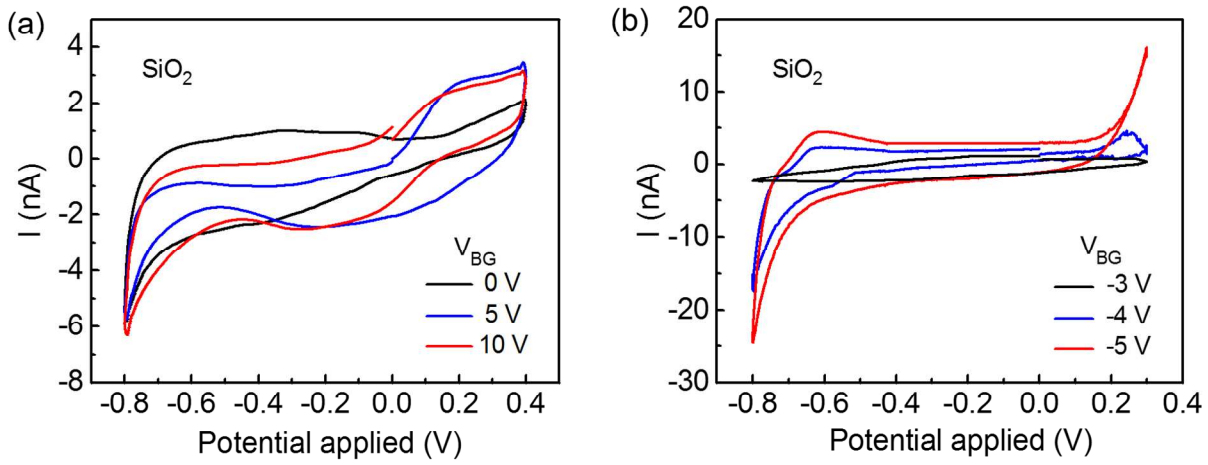

Figure S4. The cyclic voltammograms of the top-gate OFET with SiO_2 as the bottom gate dielectric layer at (a) positive bottom gate biases; (b) negative bottom gate biases.

Although the DG-OFET devices with thermal oxide (SiO_2) bottom gate dielectric are stable at high positive bottom gate biases ($+10$ V), redox reactions take place when the negative V_{BG} exceeds -5 V (Figure S3b), leading to the breakdown of oxide dielectric.

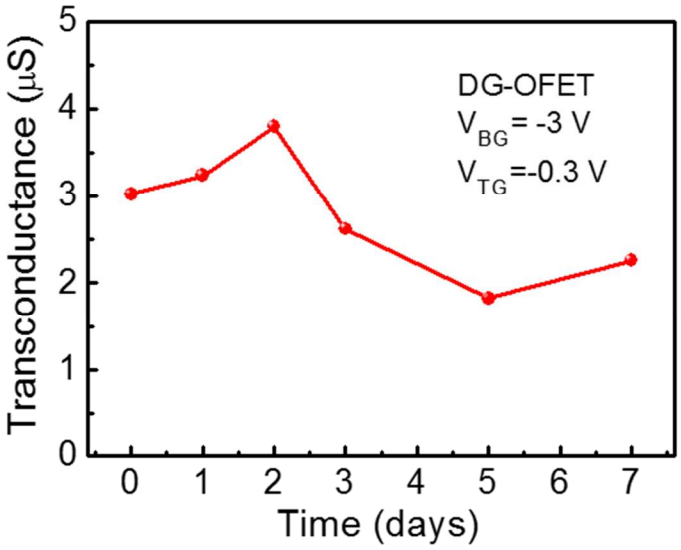

Figure S5. The transconductance of DPP-DTT EGOFET versus time at $V_{BG}= -3$ V, $V_{TG}= -0.3$V.

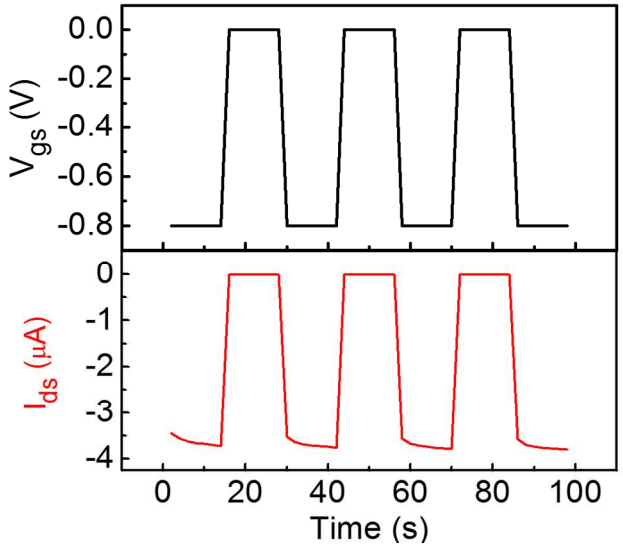

Figure S6. Temporal response of the DPP-DTT EGOFET (bottom) to "ON-OFF" stress of the gate voltage (time).

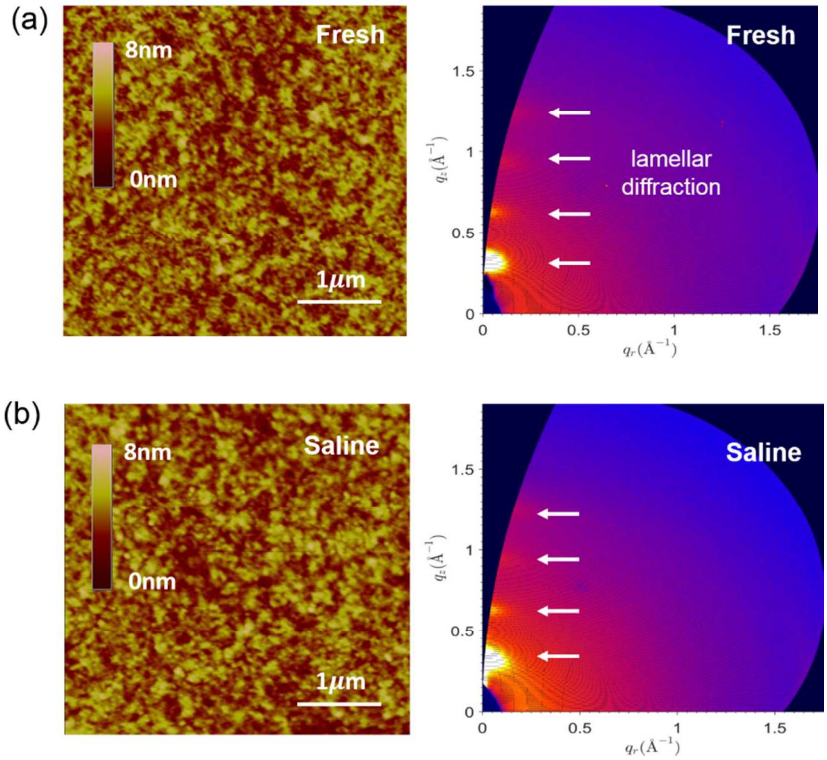

Figure S7. AFM (left) and GIWAXS (right) patterns of (a) fresh prepared DPP-DTT film and (b) DPP-DTT film after test under physiological saline solution.

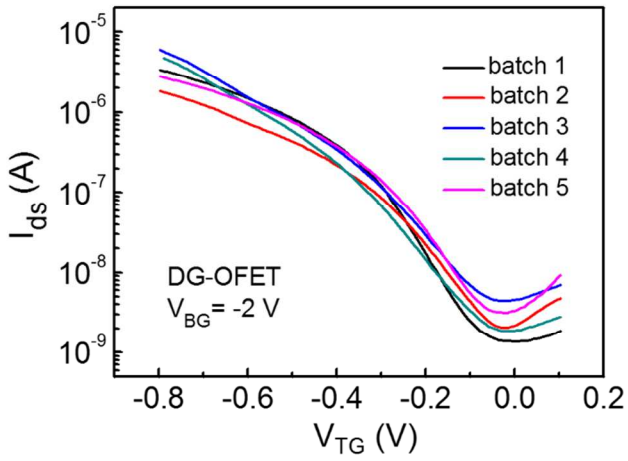

Figure S8. Transfer characteristics of DG-OFET from 5 different batches with the bottom gate bias kept at −2 V.

Table S1. Threshold voltage and mobility of devices from 5 batches

	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
Threshold voltage V_{th} (V)	−0.137±0.03	−0.137±0.07	−0.128±0.05	−0.166±0.03	−0.134±0.06
Mobility ($\times 10^{-2}$ $cm^2V^{-1}s^{-1}$)	2.10±0.4	1.43±0.2	2.49±0.5	2.12±0.6	1.83±0.5

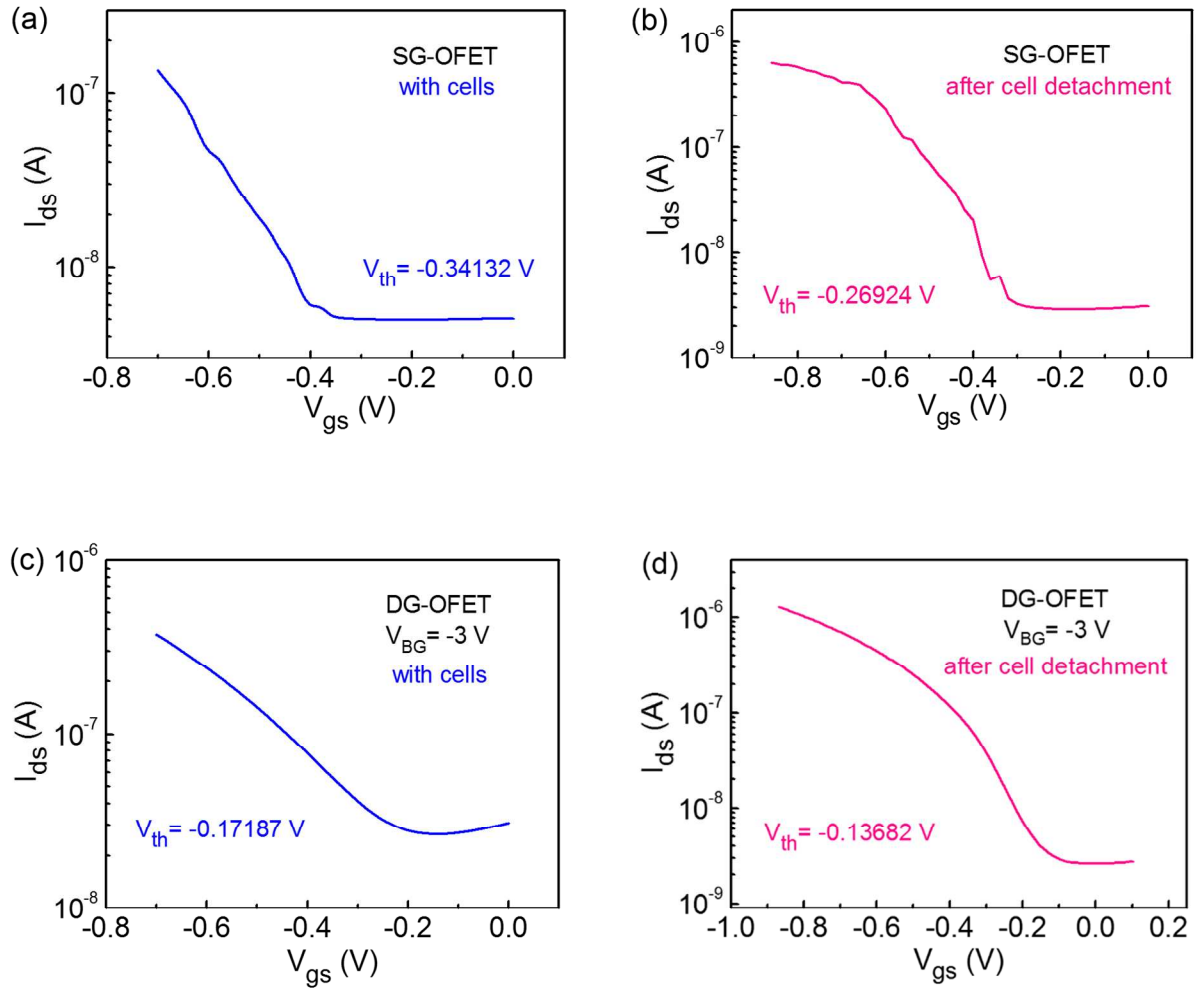

Figure S9. Transfer characteristics of a SG-OFET with hMSCs seeded on top of the DPP-DTT film (a) and after cell detachment (b); DG-OFET with hMSCs (c) and after cell detachment (d).

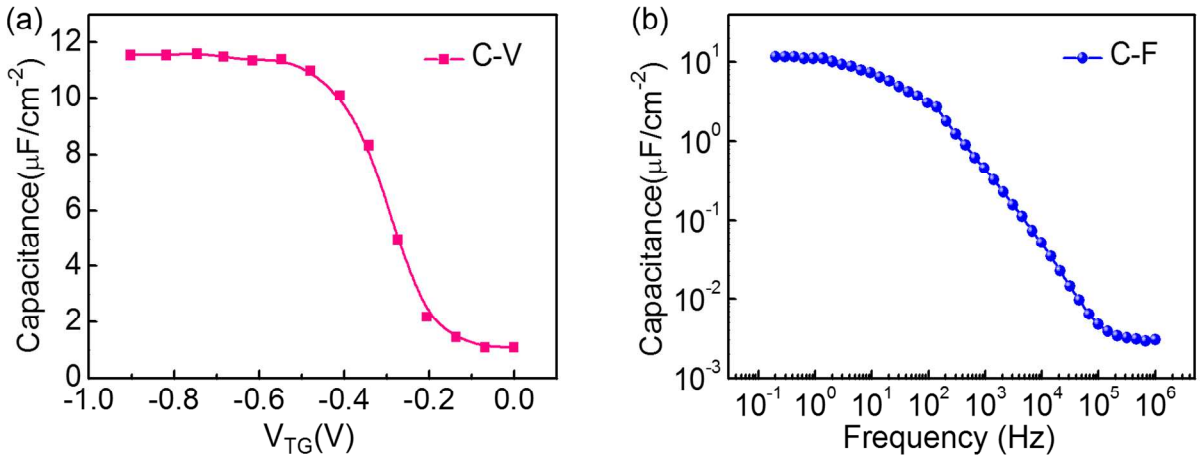

Figure S10. (a) Capacitance-voltage (C-V) relation of the g2T-T OECT. (b) Capacitance-frequency (C-F) relation of the g2T-T OECT.

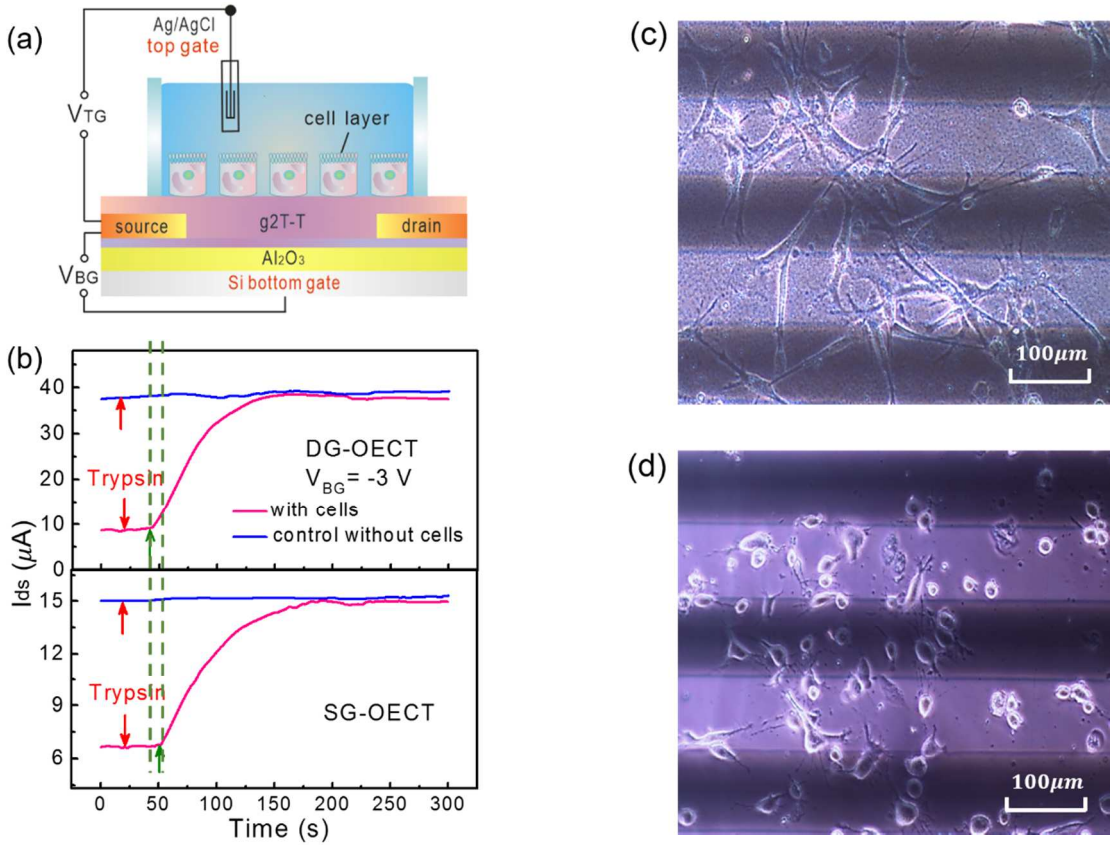

Figure S11. (a) Schematic diagram of cell-sensing with a g2T-T based accumulation mode OECT; (b) *in situ* responses of the DG-OECT (top) and SG-OECT (bottom) with (pink trace) and without (blue trace) hMSCs upon trypsin treatment (introduced at t = 20 s). The green arrows indicate the current raise of the devices. For both devices, V_{ds} and V_{TG} were kept at −0.2 V; (c) and (d) are optical images of hMSCs cultured on the OECTs before and after 5 minutes of trypsin treatment, respectively.