† Electronic Supplementary Information (ESI) available

1. Simulation results

To fabricate transparent device, Comsol multiphysics 3.5 version software was used for simulation purpose. Fig S1 shows schematic diagram form simulation and we highlighted all simulation results only on red color part (square box)

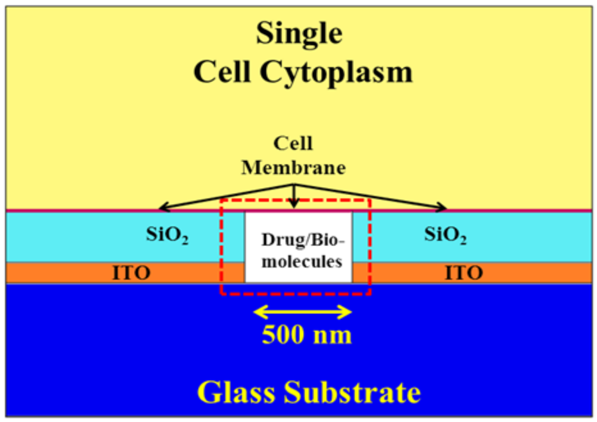


Fig S1: schematic representation of LSCNEP device for simulation. All simulation results highlighted only on red part.

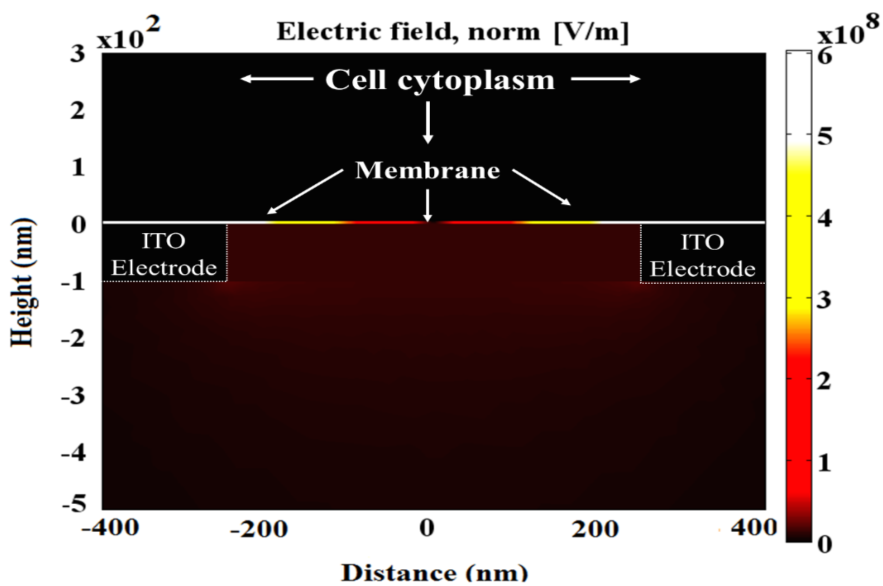


Fig S2: Electric field distribution without SiO_2 layer. The field is very high (6×10^8 Vm^{-1}) for 6V applied voltage, whereas with SiO_2 layer, the electric field was (1.8×10^8 Vm^{-1}).

The device is fabricated with 90 nm thick and 2 μm wide ITO nano-electrodes. The gaps between two nano-electrodes are 500 nm. Figure S2 shows electric field (6×10^{8} Vm^{-1}) distribution without SiO_2 layer, which is much higher when compared with SiO_2 layer (1.8×10^{8} Vm^{-1}). In Figure S3 (a), shows resistive heat (0.35×10^{12} Wm^{-3}) and TMP (3V, see Figure S3(b)) distribution on cell membrane surface without SiO_2 layer and it is much higher when compared with SiO_2 layer case. As a result, due to larger effect TMP on cell membrane surface without SiO_2 layer, stable hydrophilic nano-pores cannot reseal again and finally cell death. The viability without SiO_2 layer is lower (>30%).

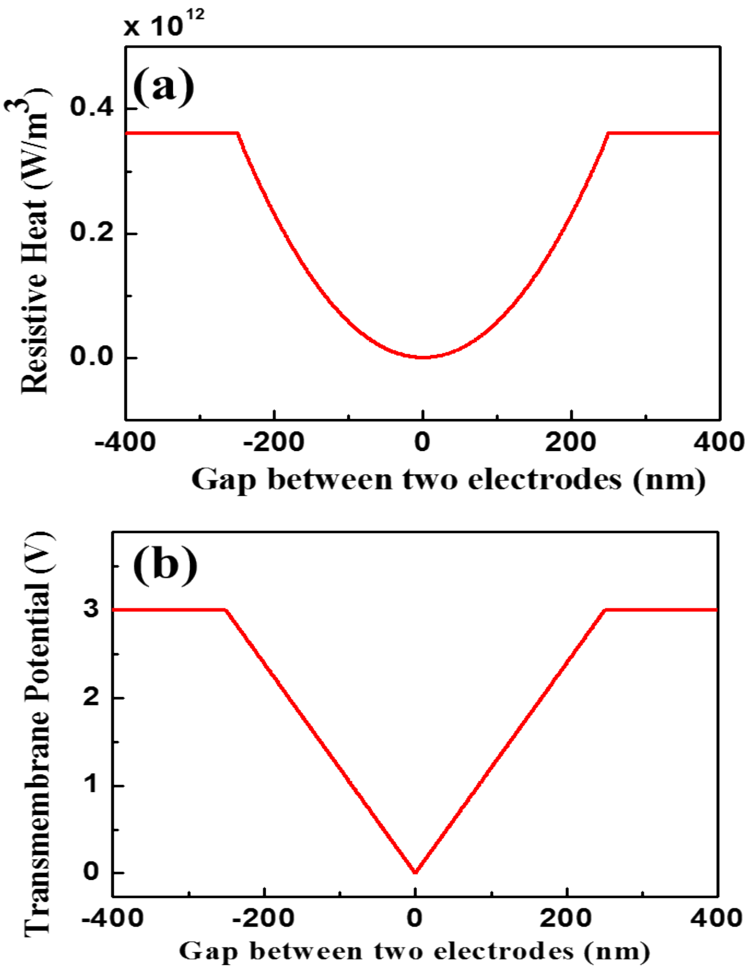
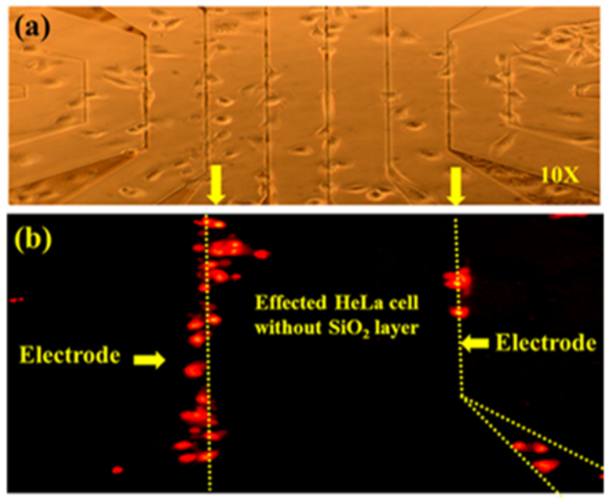


Fig:S3. (a) Resistive heat distribution profile on Hela cell membrane without SiO_2 layer consideration. (b) Transmembrane potential (TMP) distribution on cell membrane surface [maximum (3V) in contact with cell membrane and nano-electrode surface, minimum (0V) at centre of the nano-electrode gap without SiO_2layer consideration.



S4: HeLa cell affected without SiO_2 layer. Voltage applied only two electrodes without PI dye. After an hour PI dye was introduced into the chip and it is stain with nucleolus of dead cell resulting red fluorescence image (those cells attached with electrode surface) (a) optical image after electroporation (b) fluorescence image after an hour.

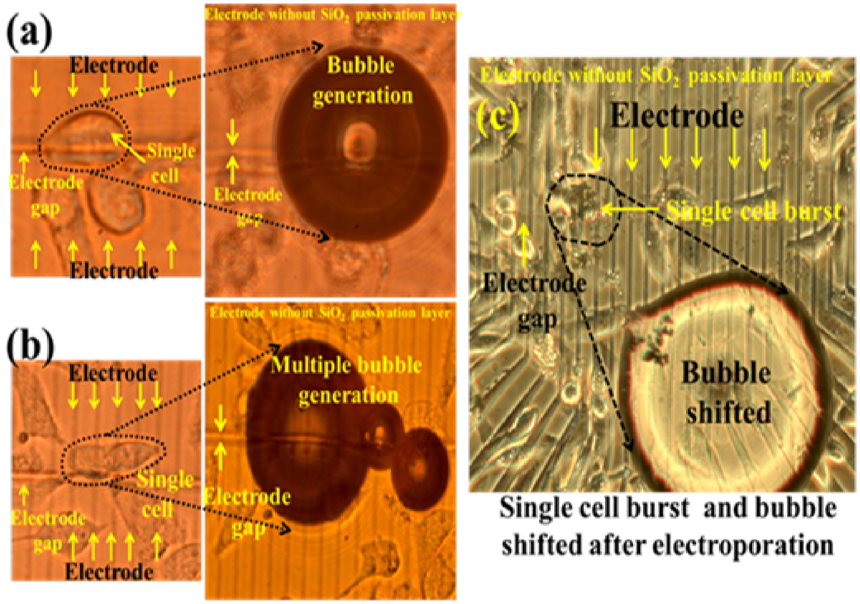


Figure S5: Bubble generation in LSCNEP chip during electroporation without SiO_2 layer (a) 3Vpp, 10 ms pulse (b) 5Vpp 10 ms pulse and (c) 6Vpp 10 ms pulse where single cell is burst after electroporation and bobble shifted from electroporation position.

2. Fabrication

To fabricate LSCNEP device, the ITO film is deposited using RF sputter and immediately annealed at 330 ^{0}C for better film uniformity and reduce the ITO resistivity

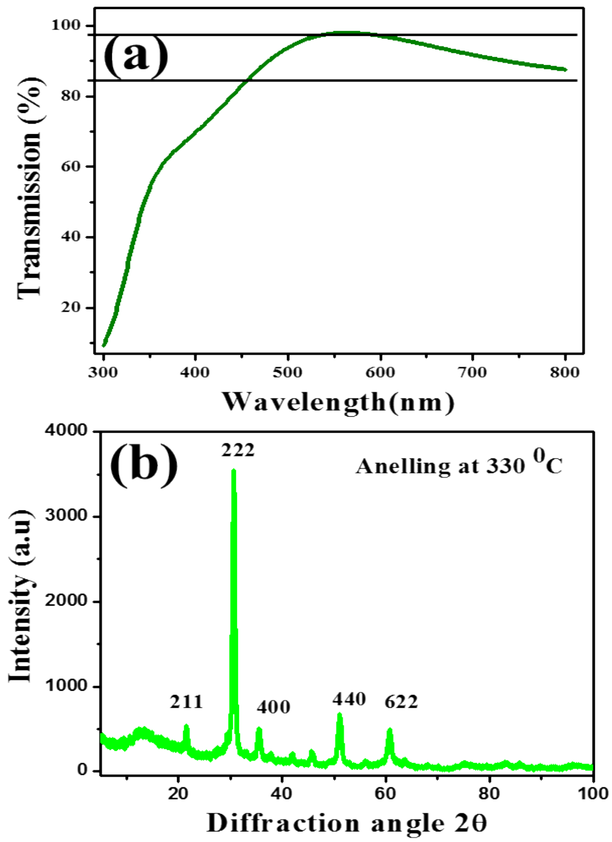


Figure S6 (a) Light transmission of Indium Tin Oxide (ITO) films by UV-VIS spectroscopy measurement (b) X-Ray diffraction of ITO films after annealing at 330 ^{0}C .

Figure S_6 (a) shows the light transmission capability by UV-VIS measurement of RF sputter deposited ITO film, where light transmission is 85-98% from 450 nm to 800 nm with visible light range. Figure S6 (b) shows the X-Ray diffraction results and confirms the good orientation with other reported results.[36]. Figure S7 shows ITO nano-electrodes with 3μm deep channel. This channel might be helpful to diffuse dyes/molecules into the cell during electroporation experiment. Figure S8 shows randomly distributed HeLa cell into chip surface after 16-20 hours incubation.

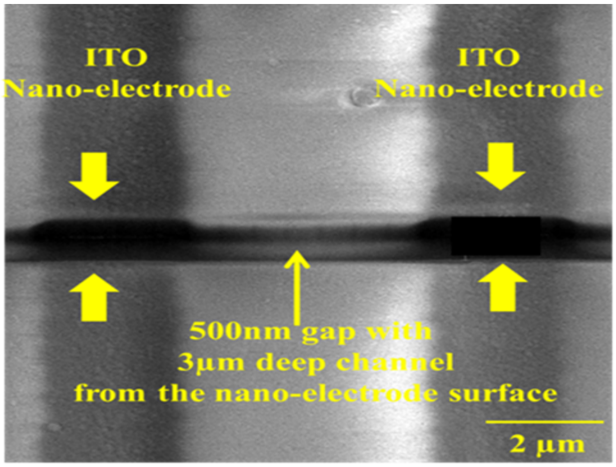


Figure S7: ITO nano-electrode form by Focused Ion Beam (FIB) technique. The electrode gap was 500 nm and depth of this gap was 3µm from electrode surface.

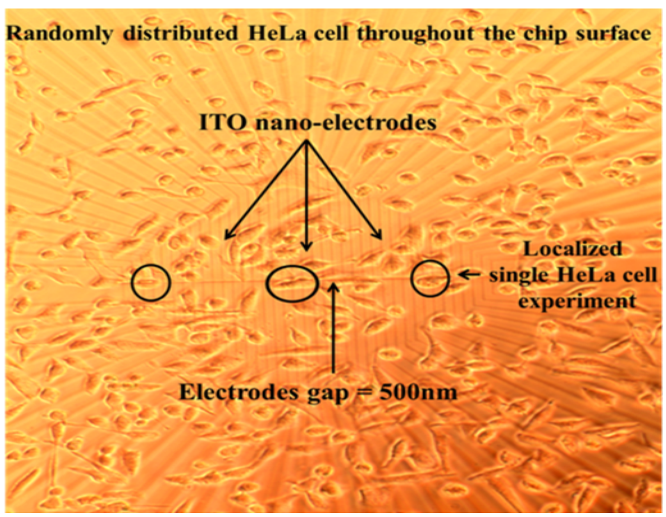


Figure S8: HeLa cells were randomly distributed throughout the LSCNEP chip surface after 16-20 hours incubation.