# Design of Dielectrophoretic Cell Traps in Microfluidics Devices Using COMSOL Multiphysics® Software

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## Abstract

Isolation of target cells from biological samples such as serum, urine or blood without contamination with other cells, in high throughput is the starting point of developing effective therapy. Currently available methods for cell isolation such as fluorescence activated cell sorting, magnetic activated cell sorting and laser micro-dissection require extra labeling. This additional step cause to contaminate and degrade target cells. To address this issue, we proposed a label free, low-cost and high-throughput technique based on dielectrophoresis (DEP). Dielectrophoresis is the motion of the particles (cells) in relation to the suspended medium when it is subjected to a non-uniform electric field. We have engineered the DEP inside microfluidics channel so that only target cells are trapped inside the microfluidics channel. Once the target cells are trapped inside the microfluidics, various immunofluorescence assays can be performed to further understand the information about these target cells.

We have used the COMSOL Multiphysics® software to design array of micro-electrodes that can trap target cells efficiently on the electrodes using DEP. We came up with two electrode designs that can generate large DEP forces on target cells for high-throughput isolation or separation from non-target cells. Moreover, these electrodes generate large electric field gradients that lead to produce large DEP forces on target cells, they are indicated in the "Figure 1(a and b)". To estimate the electric field gradients, first electrodes were drawn to a scale using AutoCAD® and imported into the COMSOL® software. The COMSOL® software was used to calculate the electric fields and electric field gradients generated by two electrodes designs. We have used the Electric Current interface of the AC/DC Module of the COMSOL Multiphysics® Software to perform a frequency domain study. By setting all the required parameters and boundary conditions such as dielectric values of cells and medium, conductivity of the medium and applied electric potential, the simulation was performed and the electric field gradients and normalized electric field strength patterns were calculated (see "Figure 2"). Finally, variations of electric field gradients were plotted along contours for comparison. "Figure 3 (a, b, c and d)" and "Figure 3 (c and d)" indicate the results.

From the simulation results, for two designs, the highest electric field gradient of $|\nabla E^2| = 2.59 \times 10^{16}$ V2/m3 is expected at the center of the electrodes and also the highest electric field gradient and normalized electric field pattern is observed at the center of the electrodes as we expected. These values will generate a highest DEP of nN on target cells therefore target cells can be traped on the center of the electrode. We have then utilized the standard micro-fabrication techniques to develop prototypes of our

design. Currently, we are performing experiments to find the purity, recovery and throughput of our device. Finally, we hope to use this device in isolating circulating tumor cells from whole blood.

## Reference

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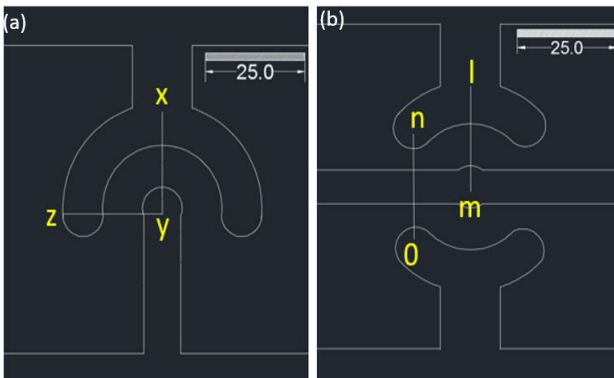## Figures used in the abstract



**Figure 1**: Electrode designs proposed for trapping cells and separating in microfluidics channels. Two electrode designs were proposed. Figure (a) and (b) indicates the two designs. Scale bars are in µm.
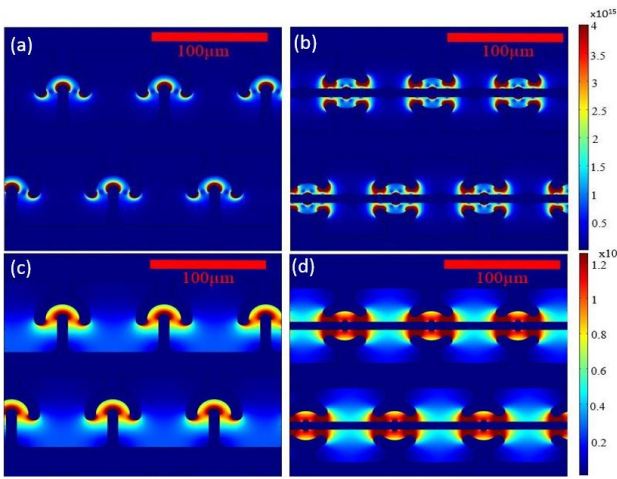
**Figure 2**: Calculated electric fields and gradients using COMSOL software. (a and b) Electric field gradient pattern of the two electrode designs in V2/m3. (c and d) Normalized electric field strength (V/m) of two electrodes designs
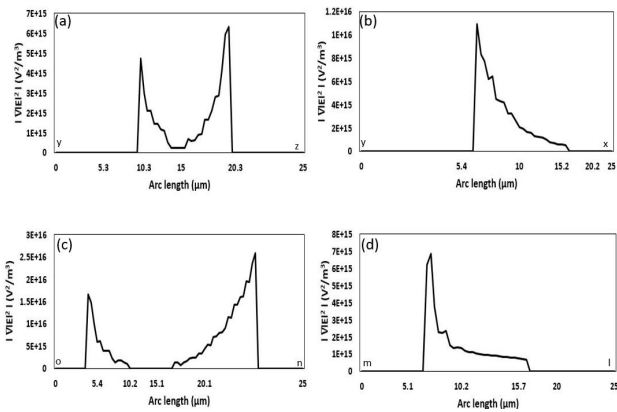


**Figure 3**: Electric field gradient analysis results of two proposed designs. (a) Variation of electric field gradient along the contour y-z in "Fig. 2(a)". (b) Electric field gradient along contour x-y in "Fig. 2(a)". (c) Variation of electric field gradient along the contour o-n "Fig. 2(b)". (d) Electric field gradient values through the cut line m-l in "Fig. 2(b)".