Design Of Dielectrophoretic Cell Traps In Microfluidics Devices Using COMSOL Multiphysics® Software

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Introduction : Isolating the target cells with high purity is the starting point of developing effective therapy for many diseases. COMSOL Mulitiphysics® was used to design dielectrophoretic (DEP) cell traps to isolate circulating tumor cells from whole blood. The DEP force, $F_{DEP} = \frac{1}{2}\alpha\, \nabla|E|^2$, depends on the electric field gradient ($\nabla|E|^2$) , therefore, we used COMSOL software to design electrode that produce large electric field gradients.

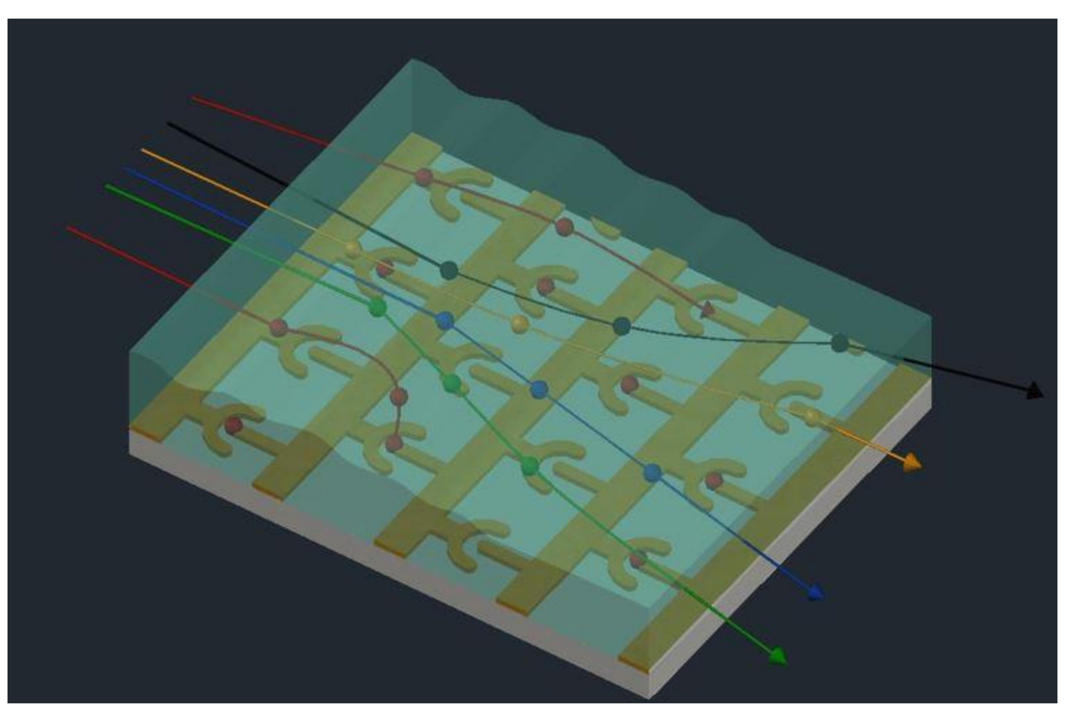

Figure 1. Conceptual view of our cell isolation device.

Computational Methods:

1.Geometry : Electrode designs were drawn according to the scale in AutoCAD software and imported to COMSOL 3D model and extruded by 100nm. Gold material was used for electrode and PBS buffer solution was filled over it and it was densely meshed into finite elements for calculations.

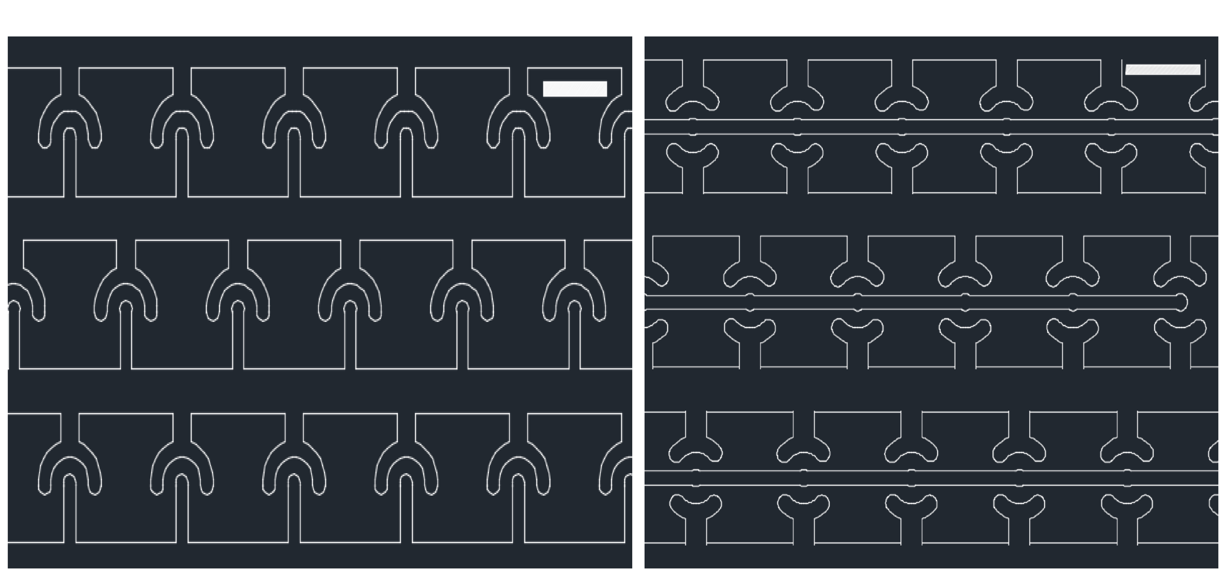

Figure 2. Electrode designs proposed for trapping cells and separating in microfluidics channels. Scale bars are 50 µm.

2.Physics and Governing Equations: AC/DC Electric current (ec) physics and frequency domain studies was utilized in calculations.

- Electric field strength was calculated by using the $\boldsymbol{E} = -\boldsymbol{\nabla V}$ equation, and the electric field gradient ($\nabla|E|^2$) was calculated in X-Y plane by using the equation

$$Grad = \sqrt{\left(\frac{d(ec.normE^2)}{dx}\right)^2 + \left(\frac{d(ec.normE^2)}{dy}\right)^2}.$$

Results: We have calculated E and ($\nabla|E|^2$) in X-Y plane and Y-Z plane, and plotted the ($\nabla|E|^2$) through the cut lines.

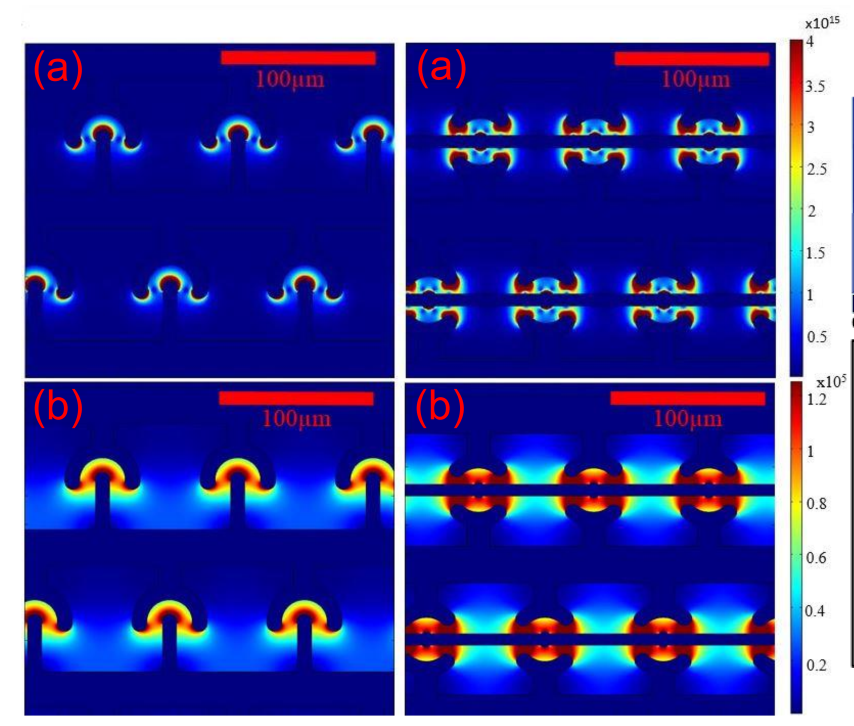

Figure 3. Calculated (a) ($\nabla|E|$^2) and (b) E ,in X-Y plane

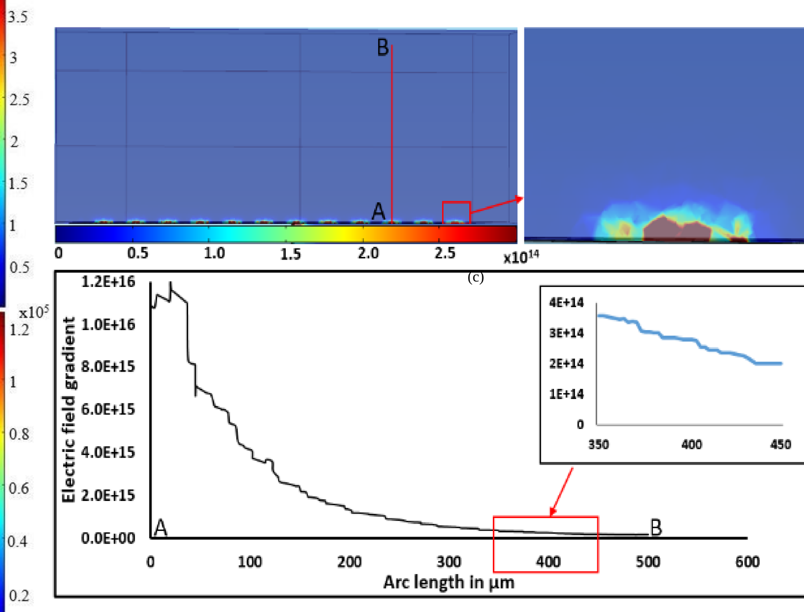

Figure 4. Calculated ($\nabla|E|^2$) in Z direction.

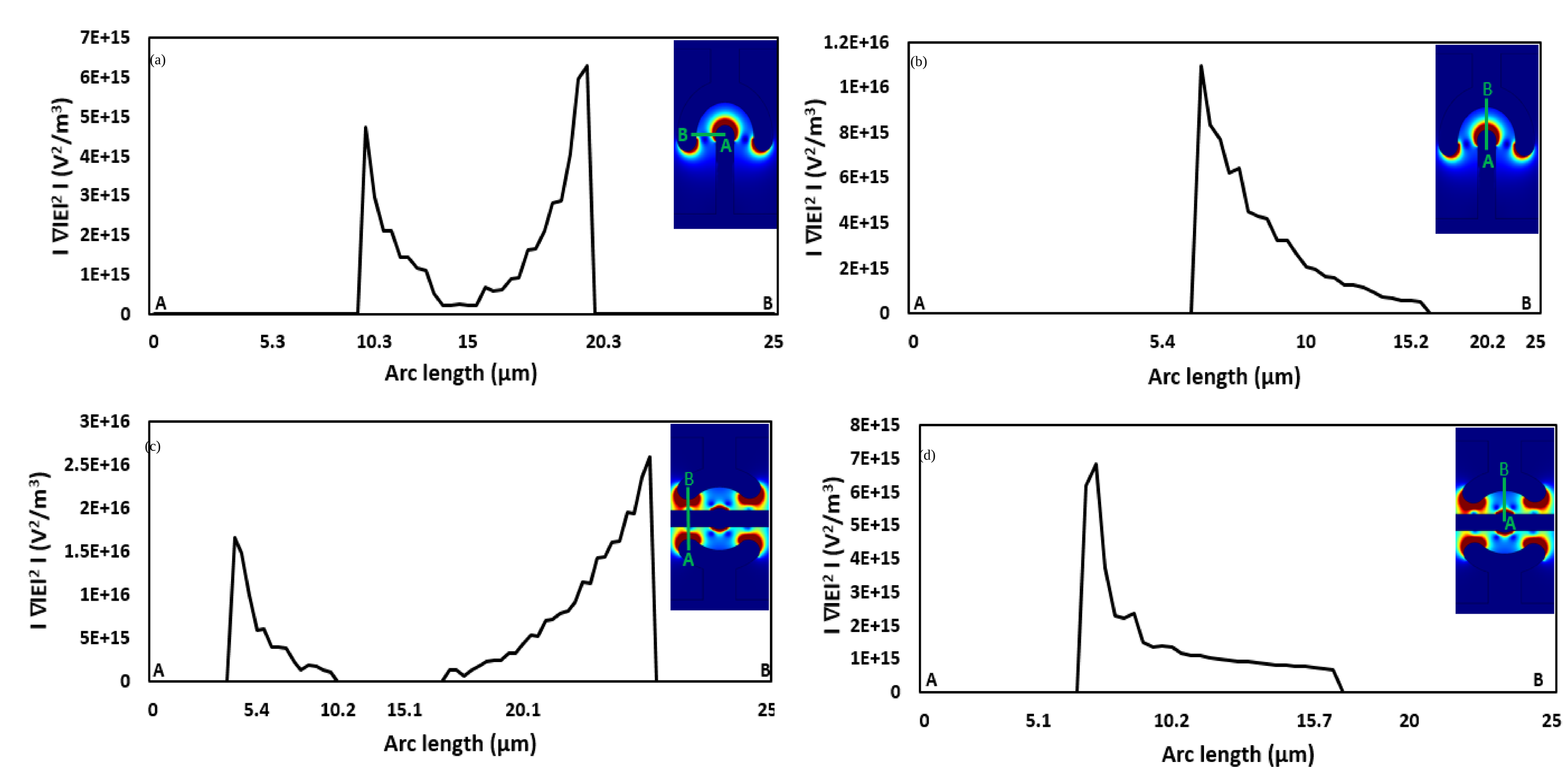

Figure 5. Calculated ($\nabla|E|^2$) through cut lines in X-Y plane.

The maximum ($\nabla|E|^2$) in X-Y plane is 2.59x10^{16} V^2/m^3 and 400 nm height was determined for the microfluidic channel.

Conclusions : We successfully utilized AC/DC ,electric current (ec), physics and frequency domain studies to calculate E and ($\nabla|E|^2$) , generated by the electrode cell trap. We fabricated the electrode using photolithography process following by metal deposition and lift off process . Currently experiments are being performed to find out the throughput of the electrode cell traps.

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