Electrohydrodynamic Micropump Modeling for Performance Optimization

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PUMP PRINCIPLE & MECHANISM

- Electrohydrodynamic pumps

$$F = qE + P \cdot \nabla E - \frac{1}{2} E^2 \nabla \varepsilon + \frac{1}{2} \nabla \left(E^2 \rho \left(\frac{\partial \varepsilon}{\partial \rho} \right)_T \right)$$

- Ion-drag principle

- Mechanism of the pump

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BENEFITS OF EHD MICROPUMP

- Robust design
- No moving parts
- Easy to fabricate
- Miniature design
- Low power consumption

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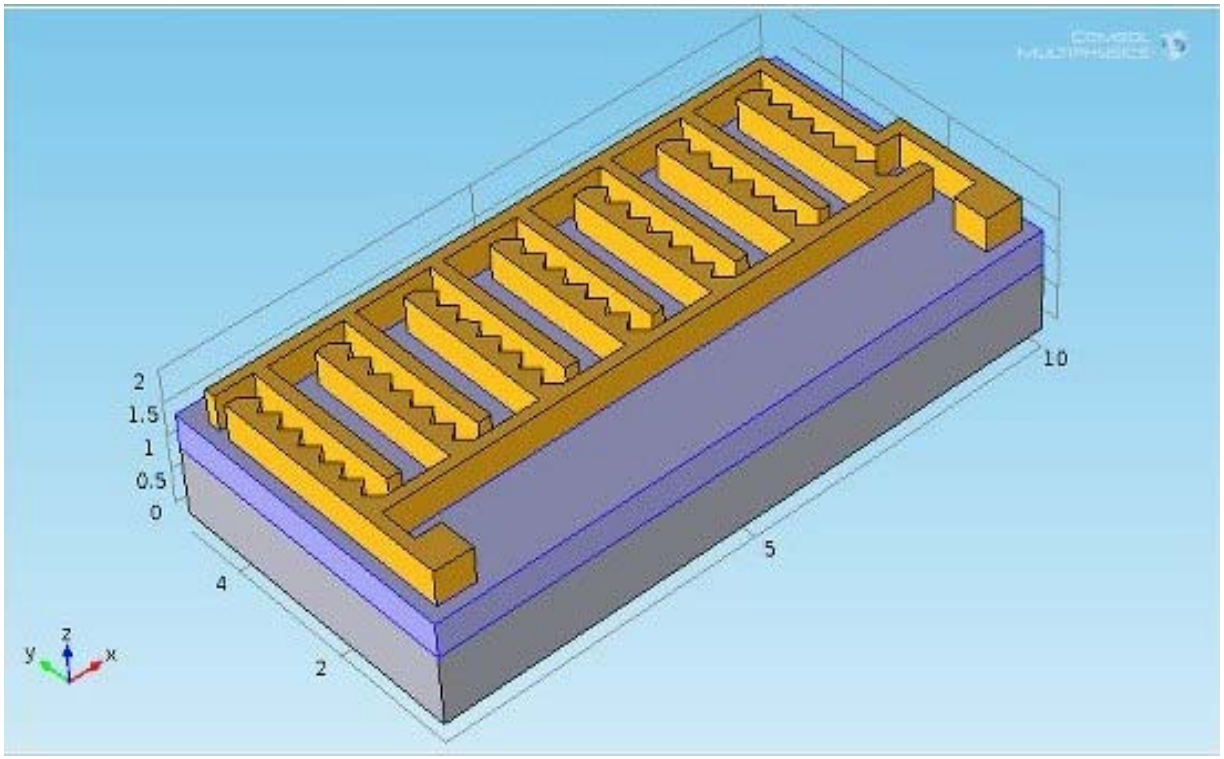
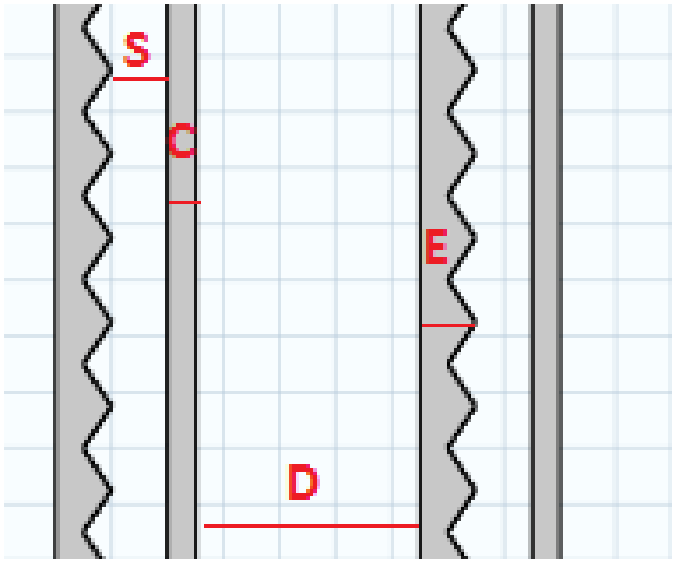
Model Prototype

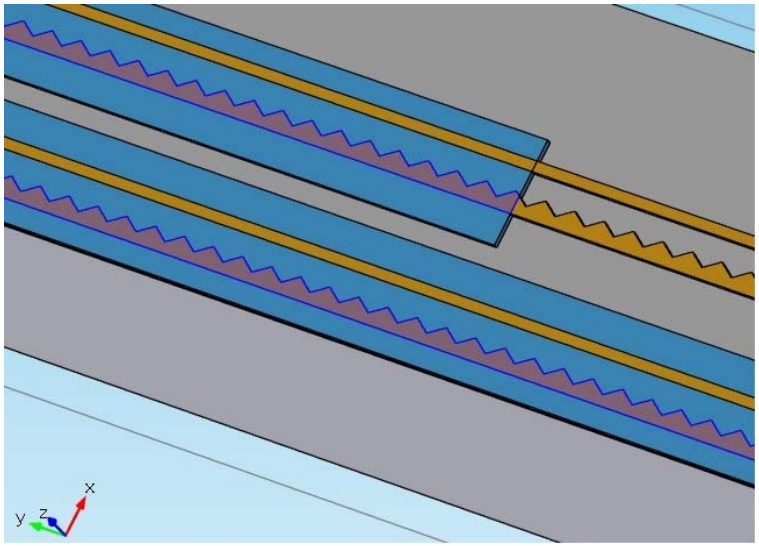


Modules Used:

1. AC/DC
2. Fluid flow
3. Structural Mechanics
4. Heat Transfer

Building Geometry in COMSOL





E	C	S	D
20um	10um	20um	80um

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SIMULATIONS & RESULTS

- Joule Heating results on Si-Au pair

Electrical Conductivity of water	Operating Voltage (V)	Low temperature limit (K)	High temperature limit (K)
σ= 5.5e0	5	295.41	2727.4
	10	303.08	435.19
	20	336.17	896.75
	40	436.61	2727.4
σ= 5.5e-4	20	289.03	296.31
	40	287.48	297.75
	80	291.09	326.95
σ= 5.5e-6	40	287.27	297.7
	200	291.96	465.23
σ= 5.5e-8	80	291.26	326.98
	200	291.26	326.98
σ= 5.5e-16	200	291.26	326.98

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SIMULATIONS & RESULTS

- Electric Field Results

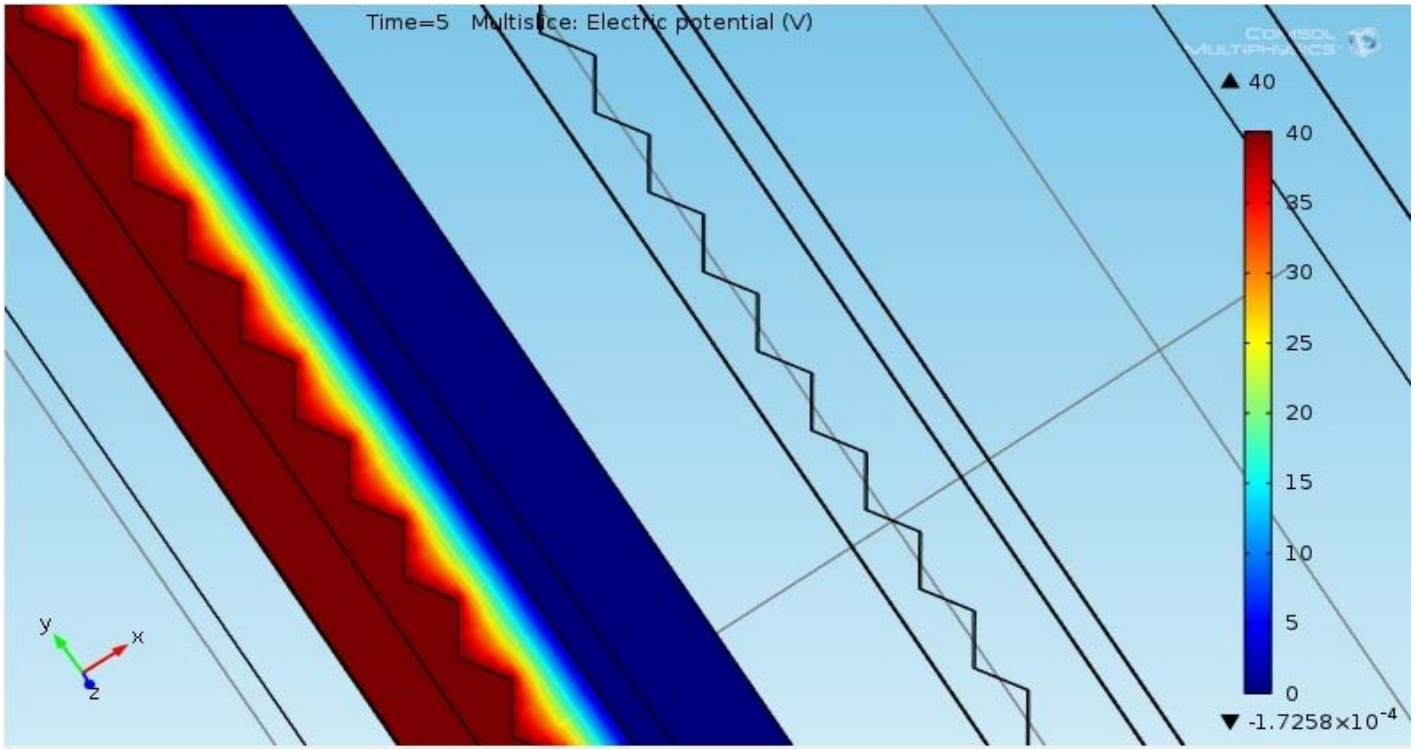
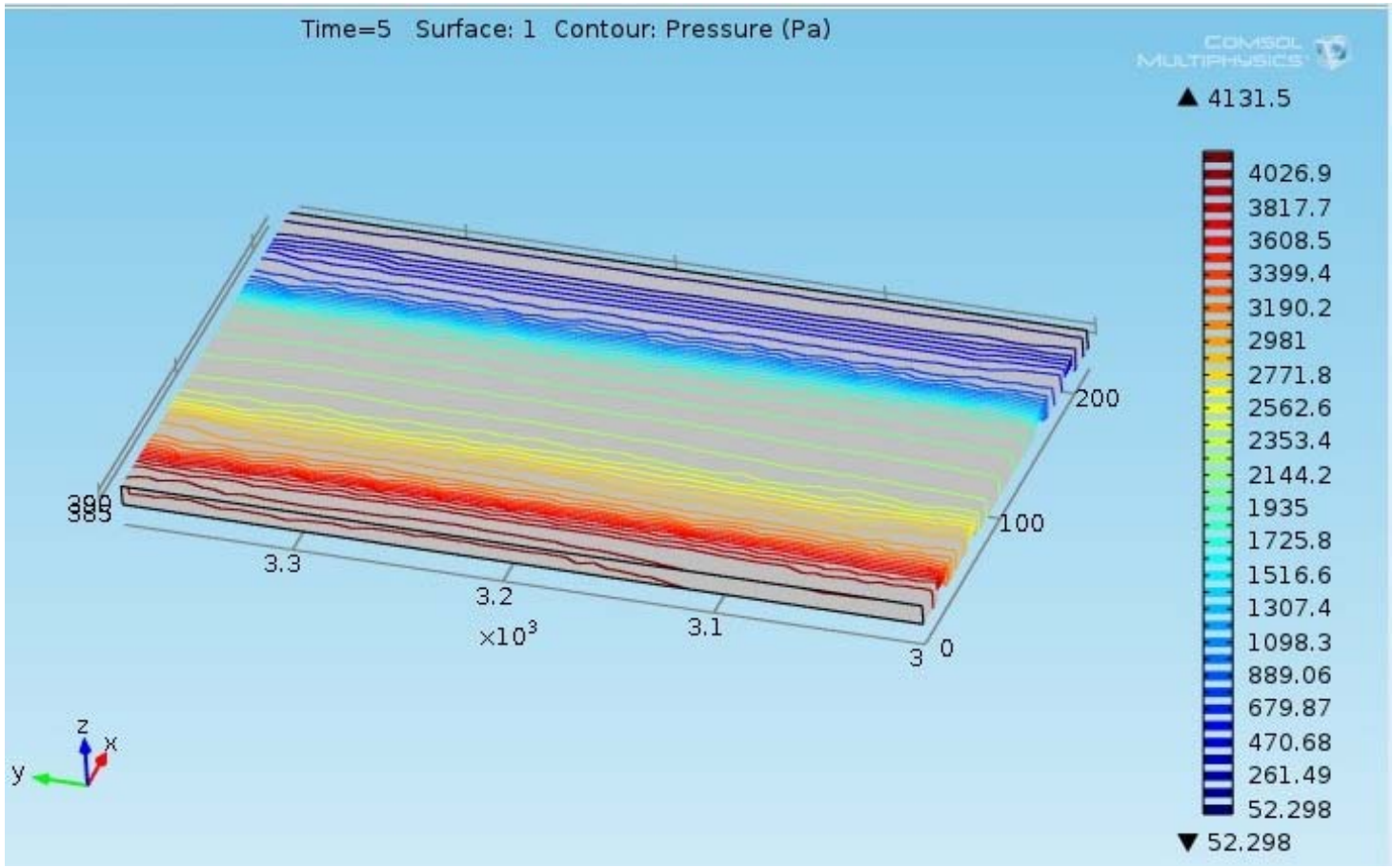


Figure showing increase in Potential gradient

- Variation in the Electric field created

Higher Limit of Electric field : 8.43 x 10^{12} V/m
Lower Limit of Electric field : 8.43 x 10^{6} V/m

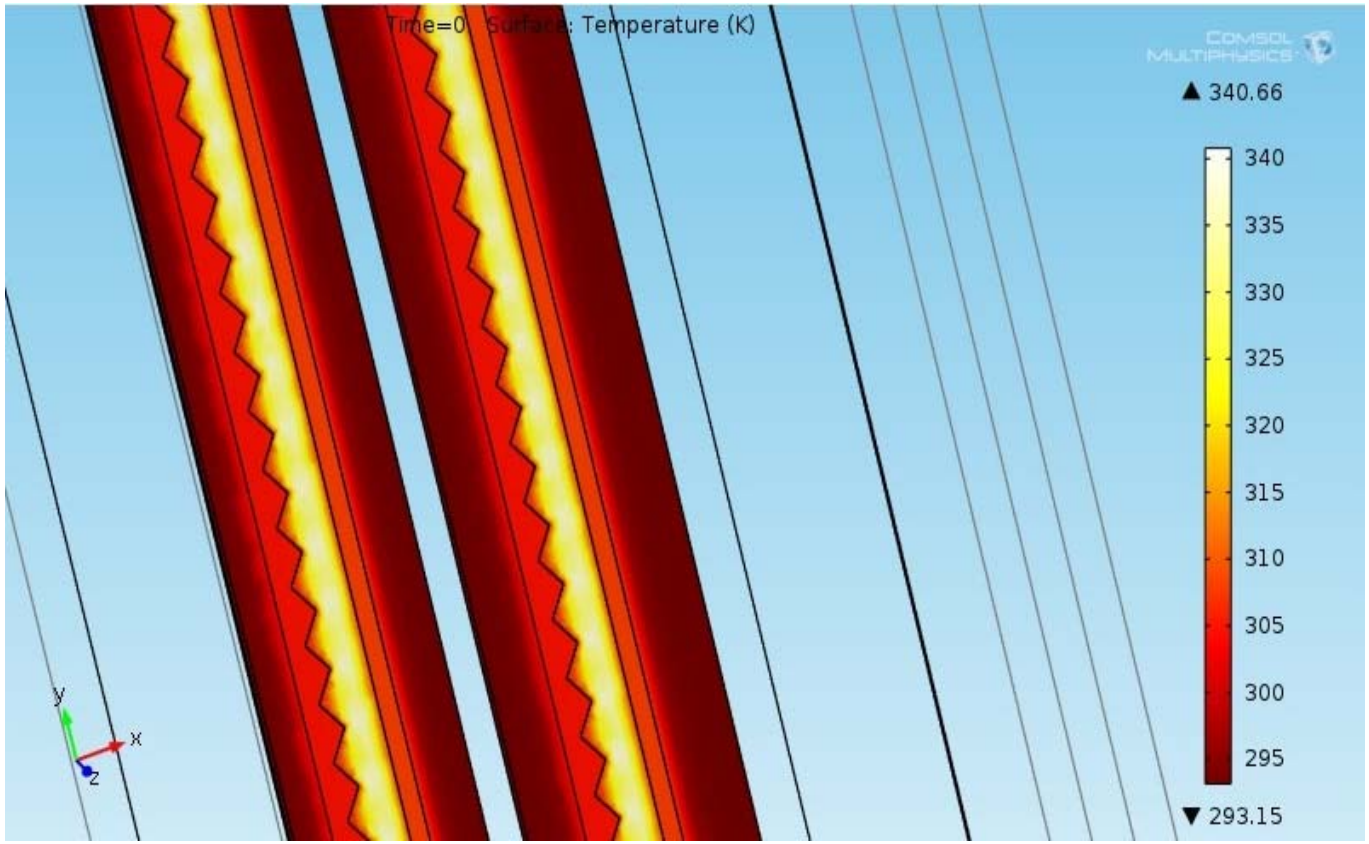
Fluid Flow & Pressure contour



ANALYTICAL CALCULATION OF INLET VELOCITY

Maximum Velocity Obtained – 8.29m/s
Minimum Velocity Obtained – 0.0082m/s

Varied Metal Thickness results



Au thickness – 10 uM with V= 10v and σ=5.5

For Au thickness – 5uM with V= 10v and σ=5.5

T_{low} =303.08 K T_{high} =435.19 K

OPTIMIZED DESIGN OF THE PUMP

- Minimize the joule heating
- To maximize the electric field at every point
- Thickness of the electrode
- Operating voltage range
- Fabrication of the substrate
- Current density on the electrode

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APPLICATIONS

- Microfluidic systems
- Bio-MEMS and MEMS analysis systems
- Drug delivery
- On chip cooling

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THANK YOU…

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