Fast Biofluid Transport of High Conductive Liquids Using AC Electrothermal Phenomenon, A Study on Substrate Characteristics

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Introduction:

AC electrothermal flow is based on permittivity and conductivity gradients caused by Joule heating effect. Substrate thermal characteristics can affect the heat transfer throughout the system and consequently change the ACET micropump performance.

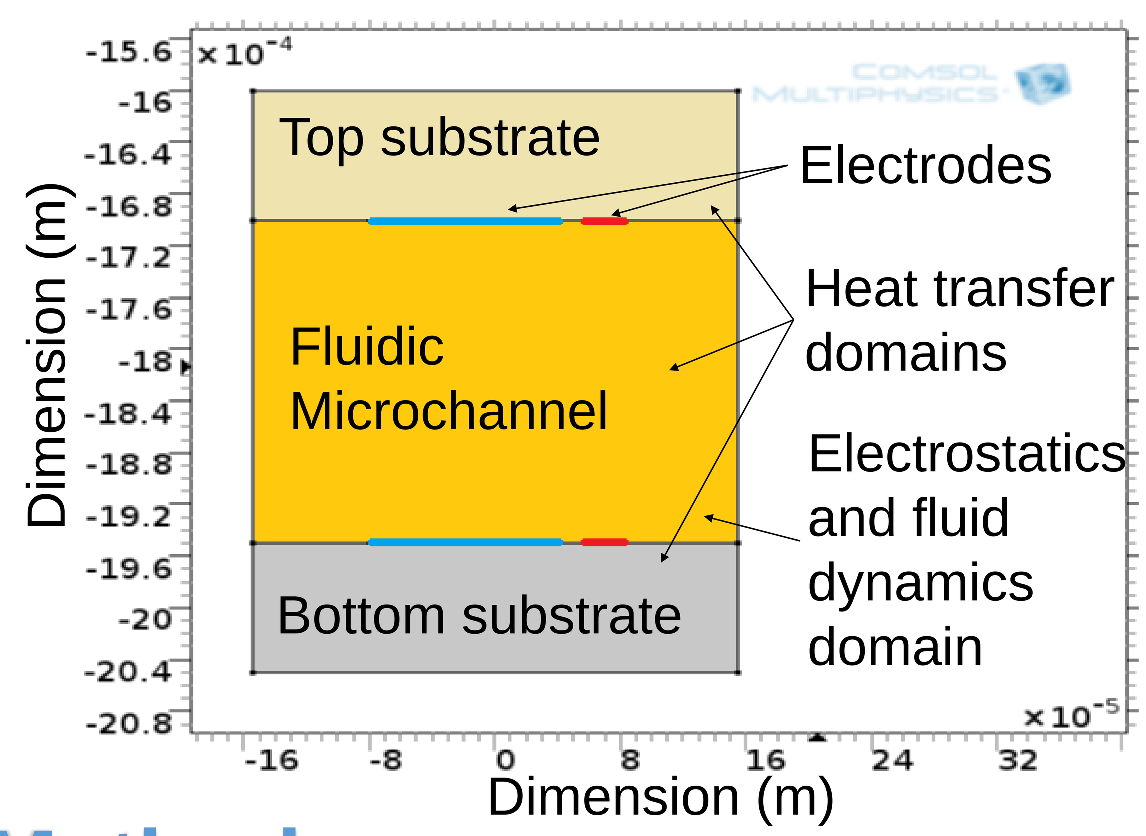

Figure. 1 The ACET micropump geometry

Computational Methods:

The ACET flow modeling includes:

- *Electrostatics* by solving Laplace equation to determine the electric field distribution;
- *Heat transfer* in liquids and solids by solving energy conservation equation to achieve the temperature gradient throughout the system;
- *Laminar flow* by solving Navier-Stokes equation to obtain the resultant ACET flow regime.

Results:

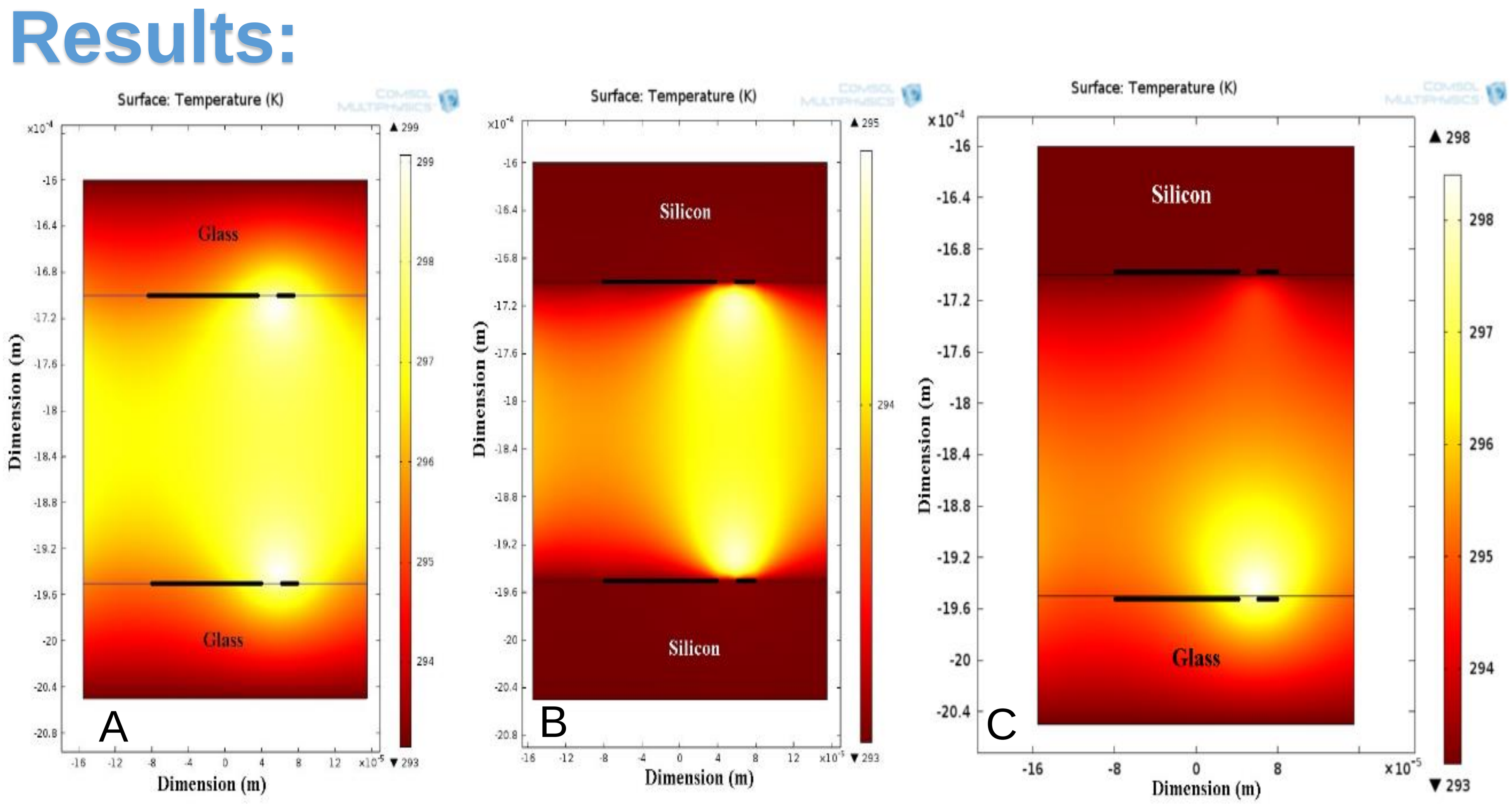

Figure. 2 Temperature distribution in three micropumps; (A): glass-glass; (B): silicon-silicon; (C): silicon-glass. Higher thermal conductivity of silicon causes it to sustain negligible temperature gradient, while ≈5 ° K temperature drop is observed in glass substrate. freq=100 kHz, σ=0.224 S/m, $V_{rms} = 7$.

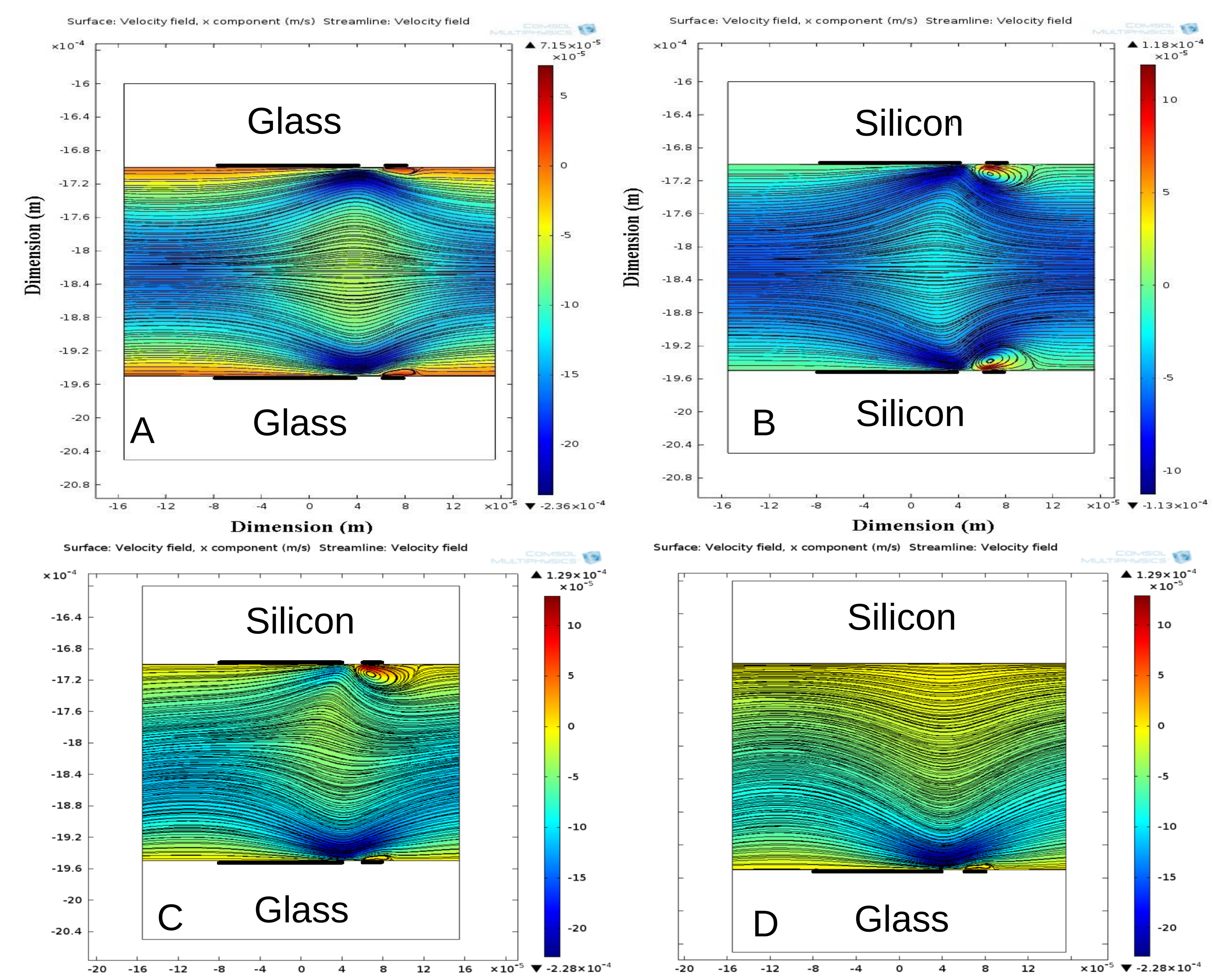

Figure. 3 ACET fluid flow for four different ACET micropump configurations; different substrate materials used as (A): glass-glass, (B): silicon-silicon, and (C): silicon-glass. (D): shows a micropump with one array of microelectrodes placed at the bottom of the fluidic microchannel. Glass-glass configuration provides the highest flow rates than the others. Also, maximum ACET velocity (x-component) occurs near the electrodes' edge. Moreover, net flow generated near the glass substrates suppresses the ACET vortices formed on top of the thin electrodes. This does not happen for the vortices near silicon substrates, as the net flow at this area has less strength. In all configurations, thin electrode is actuated at $V_{rms} = 7$, and wide one is grounded. *freq=100 kHz, σ=0.224 S/m.*

Conclusions:

- Maximum electric field and ACET flow velocity occur near the thin electrode;
- In ACET micropump with glass substrate the vortices generated near the electrode surfaces are suppressed causing in a higher net flow rate compared to that of silicon substrate;
- Increasing substrate thickness can increase the thermal resistance and cause higher flow rates up to 12%;
- Two-row electrode configuration increases the ACET velocity up to 200%.

References:

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