Sensitivity Optimization of Microfluidic Capacitance Sensors

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Introduction: Finding out dielectric constant of small quantities of fluid, usually in a lab-on-a-chip is a challenge, especially off the chip. Here, we demonstrate the design of a device [1] for on chip dielectric constant measurement and optimize its sensitivity.

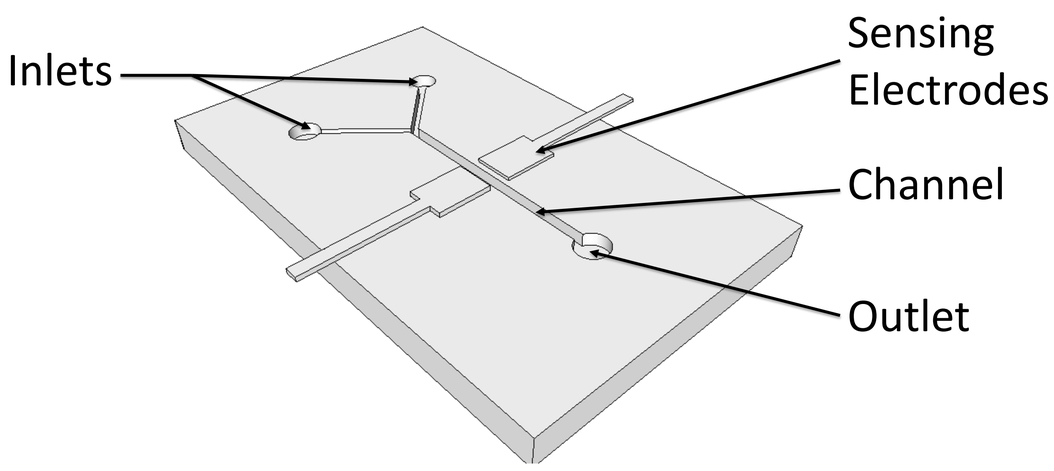

Figure 1. Title of the figure

Computational Methods: We parameterized the geometry of the device first. Boundary conditions on the source (electrodes) were applied, dielectric constants added to material properties and parametric sweeps were done. Capacitance was extracted post study. The Equations used were

$$\nabla.(\varepsilon_0\varepsilon_r\boldsymbol{E}) = \rho_v$$
$$\boldsymbol{E} = -\nabla V$$

The fluidic channel is separated from the electrodes by an insulating layer of polymer. The device itself, sits on a glass substrate

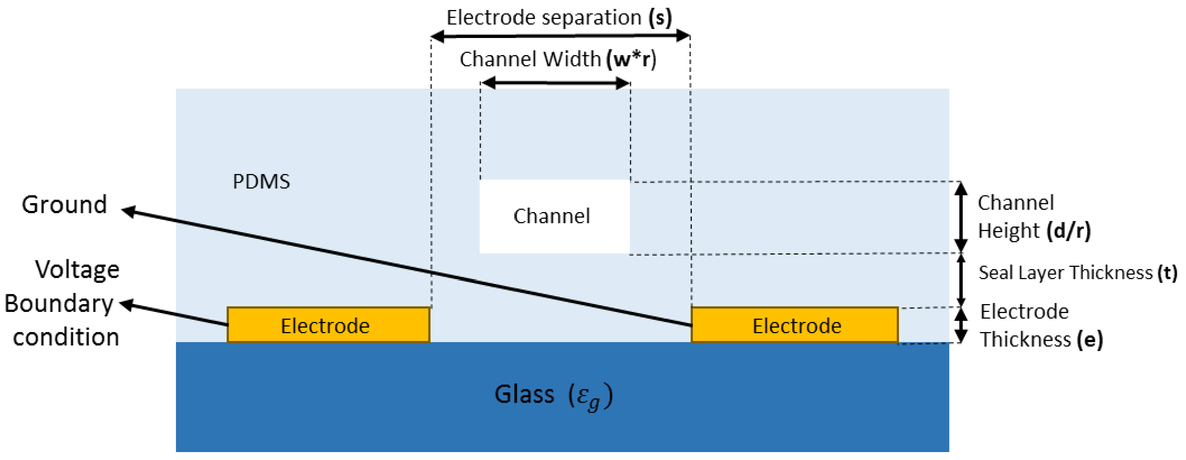

Figure 2. Geometry and Applied Conditions

Results: The capacitance dielectric constant relationship was first obtained and a metric of sensitivity was defined. The sensitivity for different geometries was thus calculated.

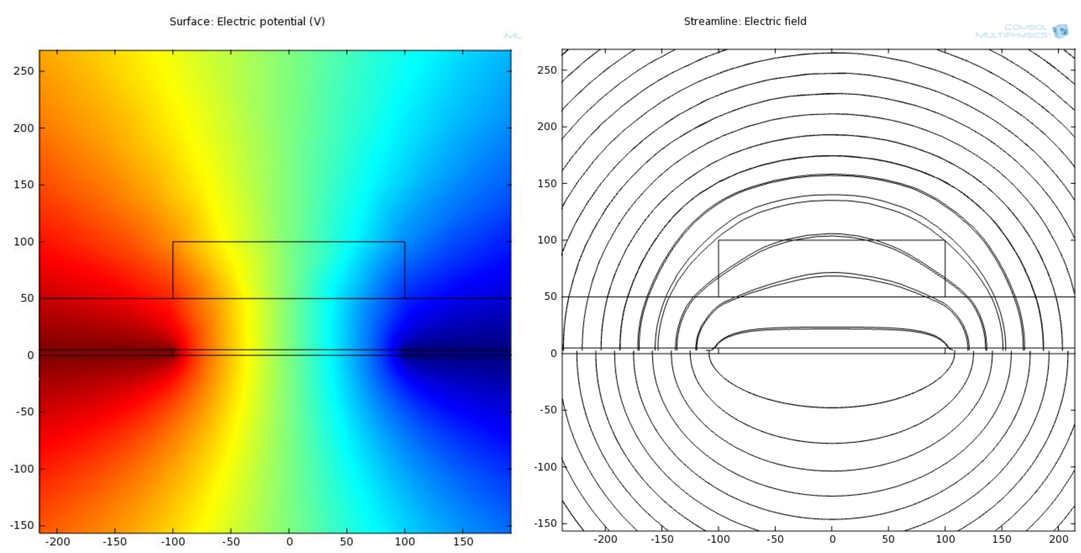

Figure 3. Electric Potential

Figure 4. Field Lines

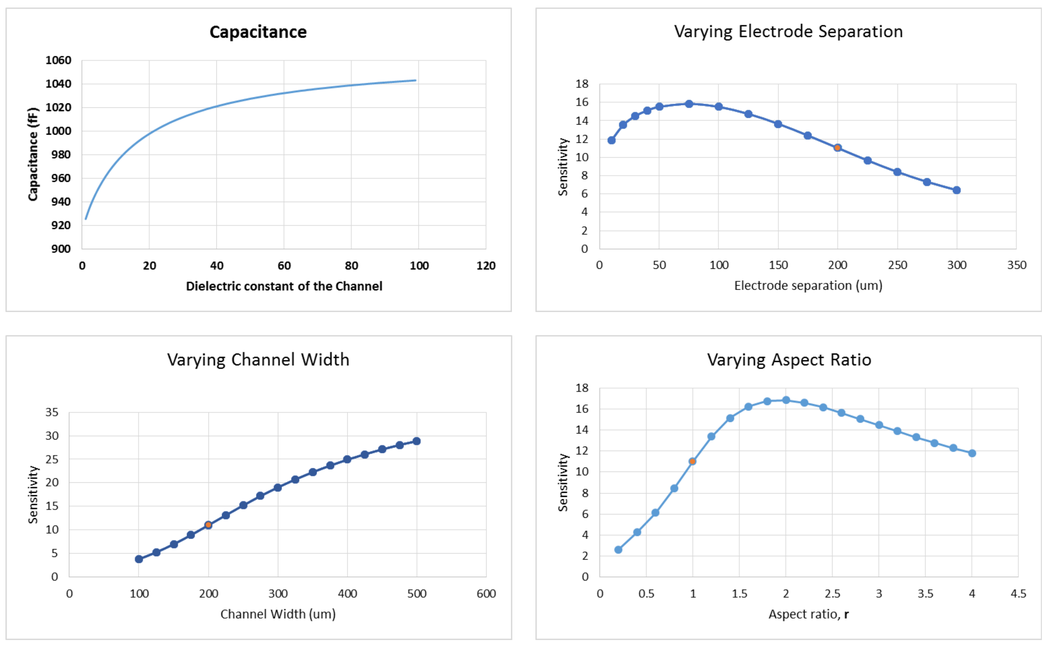

Figure 5. Trends on Variation of Parameters

Conclusions: We have obtained relations between parameters that lead to the maximum sensitivity of the device. This can lead to accurate sensors that can be used for biomedical applications too. This device is currently under fabrication at CEN, IIT-Bombay.

References:

1. M. Demori et al, “A microfluidic capacitance sensor for fluid discrimination and characterization **”,** *Sens. Act. A*, Volume 172, Issue 1, Pages 212–219 (2011)
2. James E Mark, *Polymer Data Handbook, pg 515,* 2nd edition, Oxford University Press, 1999, USA