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**Master Thesis Defense**

Entitled

*PLANAR CORRUGATED ELECTRODE CONFIGURATION FOR MANIPULATION OF MICRO-SCALE ENTITIES IN DIELECTROPHORETIC MICROFLUIDIC DEVICES*

by

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Abstract

This thesis conceptualizes the design of a planar electrode for employment in microfluidic devices to achieve dielectrophoretic focusing and separation of micro-scale entities. The planar electrode has corrugations with two such electrodes placed parallelly to form a pair and the electric field is generated between them; the presence of corrugations enhances the non-uniformity of the electric field. For purposes of 3D focusing, two pairs of electrodes are used with each pair on either side of the microchannel. When the applied electric voltages are equal, the micro-scale entity is focused at the center of the microchannel and when the applied electric voltages are unequal, the micro-scale entity is focused at locations other than the center of the microchannel. For purposes of achieving size-based separation, four electrode pairs are used with each pair placed on one side the microchannel; the first two pairs of electrodes 3D focus the micro-scale entities next to one of the side walls while the other two pairs of electrodes subject the big micro-scale entity to negative dielectrophoresis while the small micro-scale entity experiences negligible dielectrophoresis and this pushes the big micro-scale entity into the interior of the microchannel thereby achieving the separation. The conceptualized microfluidic devices are mathematically modelled with the model consisting of multiple governing equations; equations of motion, continuity equation, Navier-Stoke equations, electric voltage and electric field equations make up the mathematical model. The model accounts the influence of phenomena such as inertia, drag, dielectrophoresis, gravity, buoyancy, and virtual mass. All equations of the model are solved numerically using Finite Difference Method. The model is validated using experimental results from literature. The model is subsequently used for understanding the influence of operating and geometric parameters on the performance metrics of the focusing and separation devices; the performance metrics of the focusing device are vertical and horizontal focusing parameters while that of the separation device include separation efficiency and separation purity. Parametric study is carried out using polystyrene microparticles suspended in water. The operating and geometric parameters studied include microchannel width/depth, electrode dimensions, volumetric flow rate, number of electrode pairs, and applied electric voltage. It is observed that the performance metrics of both the devices degrade with increase in microchannel width/depth. Based on the model, increase in applied electric voltage and volumetric flow rate leads to improvement and degradation of the performance metrics of both the devices, respectively. Increase in the electrode dimensions lead to enhancement in the focusing of the micro-scale entities. The observed variation of performance metrics with regards to operating and geometric parameters can be attributed to the influence of these parameters on residence time and electric field magnitude and non-uniformity in the microchannel. This is the first work to conceptualize the above-detailed electrode as well as to mathematically model the focusing and separation devices employing the same. A flowchart is developed for designers to use for realizing the microfluidic device, employing the conceptualized electrode for purposes of focusing and separation, with the desired performance metrics.

**Keywords:** Dielectrophoresis, focusing, planar electrodes, microfluidics, modeling, separation.