Electrical tweezer for highly parallelized electro-rotation measurements over a wide frequency bandwidth for characterizing microbial subpopulations

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Electrorotation (ROT) is a powerful tool for characterizing the dielectric properties of cells and bio-particles. However, its application has been somewhat limited by the need to mitigate disruptions to particle rotation by translation under positive dielectrophoresis (pDEP) and by frictional interactions with the substrate [1, 2]. While these disruptions may be overcome by implementing particle positioning schemes or field cages, these methods restrict the frequency bandwidth to the negative dielectrophoresis (nDEP) range and permit only single-particle measurements within a limited spatial extent of the device geometry away from field non- uniformities. Herein, we present an electrical tweezer methodology based on a sequence of electrical signals, composed of negative dielectrophoresis using 180-degree phase shifted fields for trapping and levitation of the particles, followed by 90-degree phase shifted fields over a wide frequency bandwidth for highly-parallelized electro-rotation measurements. Through field simulations of the rotating electrical field under this wave-sequence, we illustrate the enhanced spatial extent for electro-rotation measurements, with no limitations to frequency bandwidth. We apply this methodology to characterize subpopulations of *Cryptosporidium parvum* and *Clostridium difficile* with altered electrophysiology from the majority population [3] based on shifts in the electro-rotation spectra over the 0.05-40 MHz region [4]. Given the single particle sensitivity and the ability for highly parallelized electro-rotation measurements, we envision its application towards characterizing heterogeneous subpopulations of microbial and stem cells.

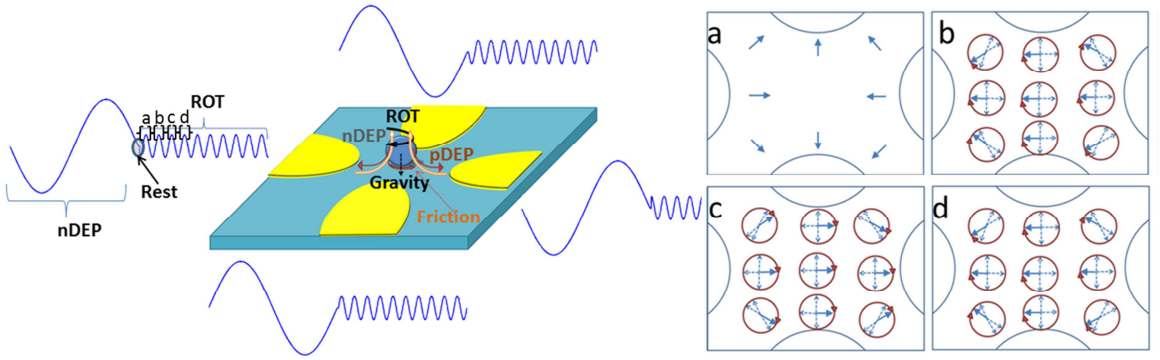


Figure 1: (left) Schematic of device geometry with the wave-sequence signal at neighboring electrodes, with simulations of the rotating electric field across the device geometry over 1 µs time periods at the four indicated time windows (a-d) under the wave-sequenced nDEP (4x) with ROT fields.

References

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