Technische Universität Braunschweig

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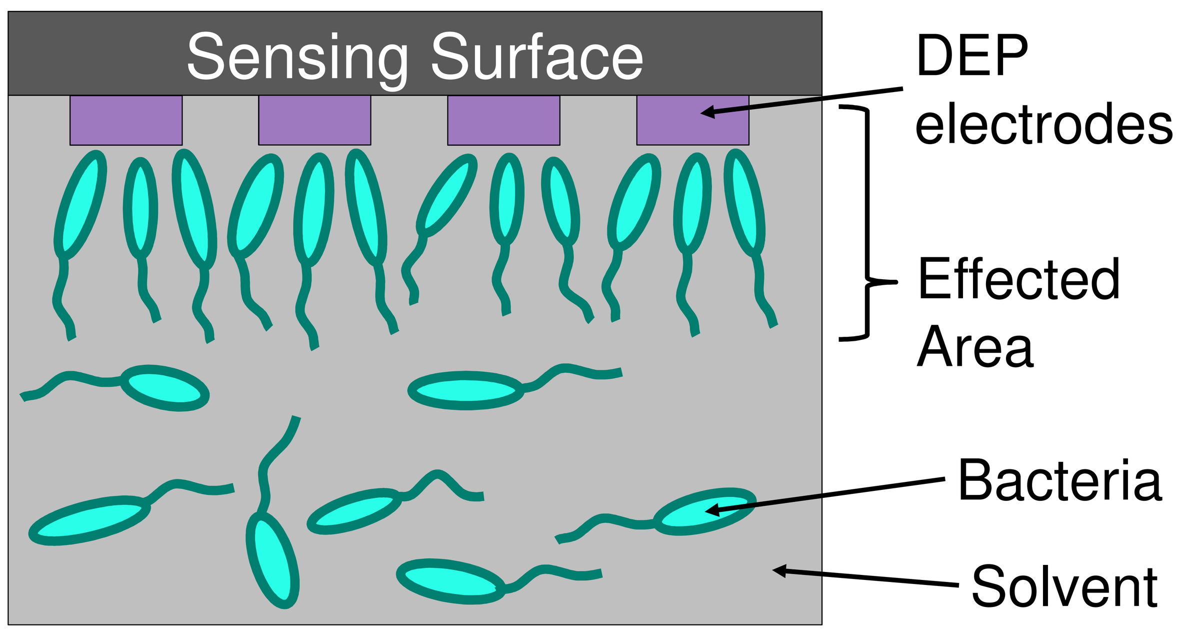
Optimizing Dielectrophoresis by Inducing Fluid Flow

M. Musiol[1,*], F. Schröder[1], A. Eckert[1], R. Biedendieck[2], H.-H. Johannes[1,3], D. Jahn[2], W. Kowalsky[1,3]
1 TU Braunschweig, Institut für Hochfrequenztechnik, Braunschweig, Germany | 2 TU Braunschweig, Institute of Microbiology and Braunschweig Integrated Centre of Systems Biology (BRICS), Braunschweig, Germany | 3 Cluster of Excellence PhoenixD, Hannover, Germany
*marten.musiol@tu-braunschweig.de

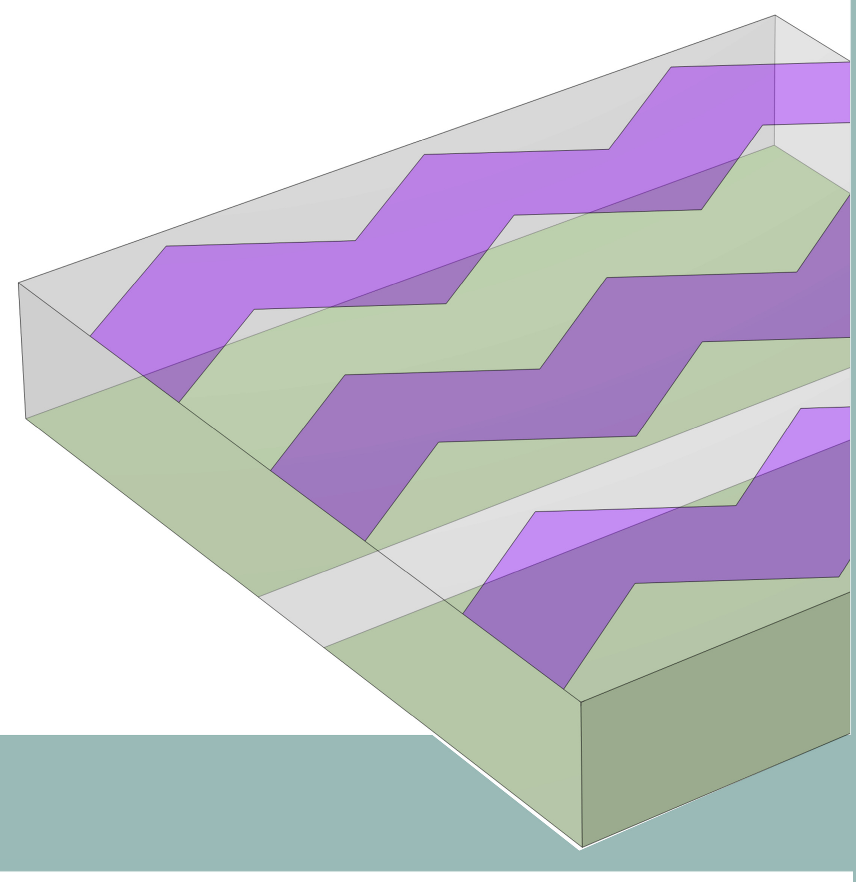
Motivation

Commonly used bacteria detection methods require a critical mass volume to detect pathogenic microorganisms. There is a great effort to **detect bacteria even at lower concentrations** to initiate medical treatment especially with regard to bacteria which are antibiotic resistant. In commonly used biosensors bacteria need to be concentrated on the electrode surface which is achieved by dielectrophoresis (DEP). Since DEP only effects a small area around the DEP-electrodes, enlarging the number of particles (in this case bacteria) in this area is of high interest.
To accomplish this an oscillating fluid flow is utilized. To investigate the effects involved **this work focuses on interactions of bacteria with DEP and fluid flow.**



Simulation Methodology

The physically relevant part of the setup is modeled in 3D, which is the border area of two electrodes generating fluid flow. The geometry additionally includes electrodes utilized for DEP on the top. To reduce computing power the thicknesses of all electrodes are neglected, and the task is split up in separate simulations, including one for fluid flow, one for DEP and one combining both.

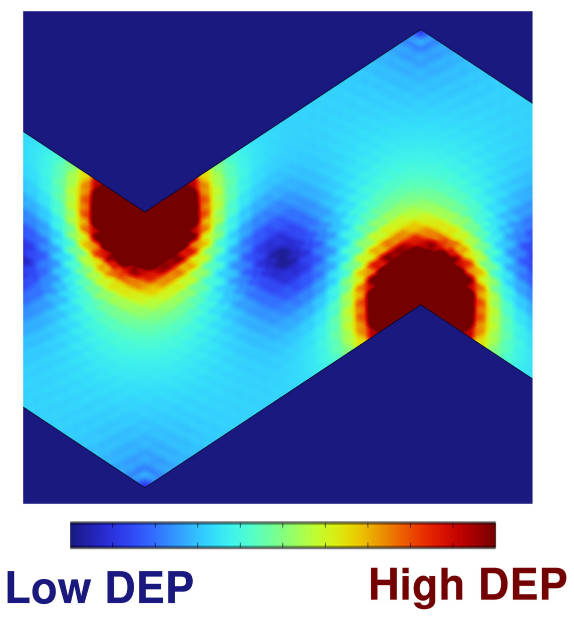


Theoretical Background

Dielectrophoresis (DEP)

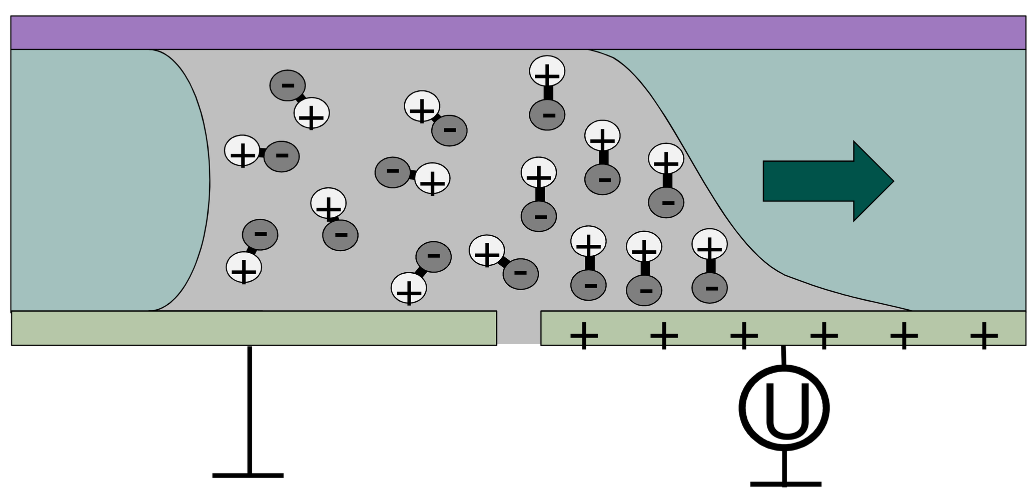
An alternating inhomogeneous electric field is applied to spatially manipulate particles (e.g. bacteria).

$$F_{DEP} \sim \nabla |E|^2$$

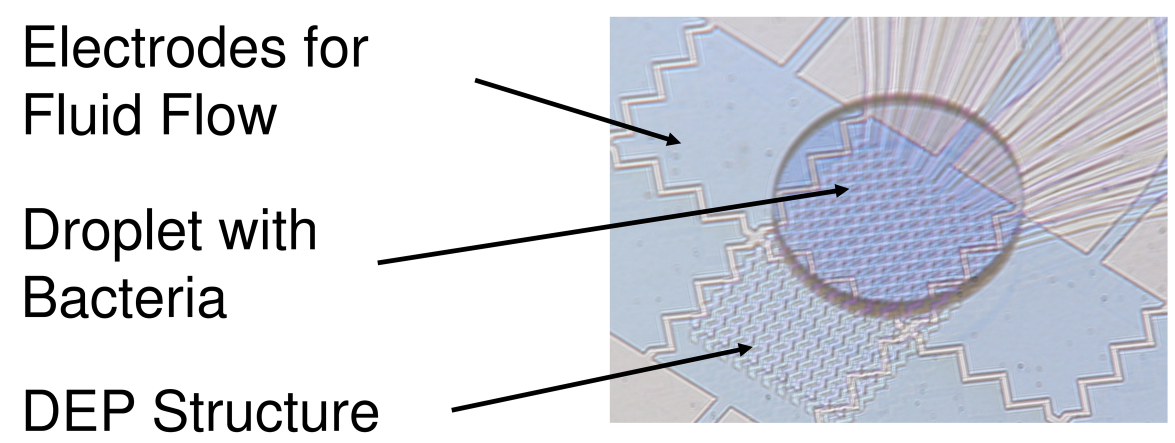


Oscillating Fluid Flow

Oscillating fluid flow is generated by changing the surface tension of a polar liquid due to alignment of its dipoles. This alignment is induced by an electric field. If the electric field is frequently changing its orientation the transport direction is also changed, leading to an oscillation.



Experimental Setup



Simulation Results

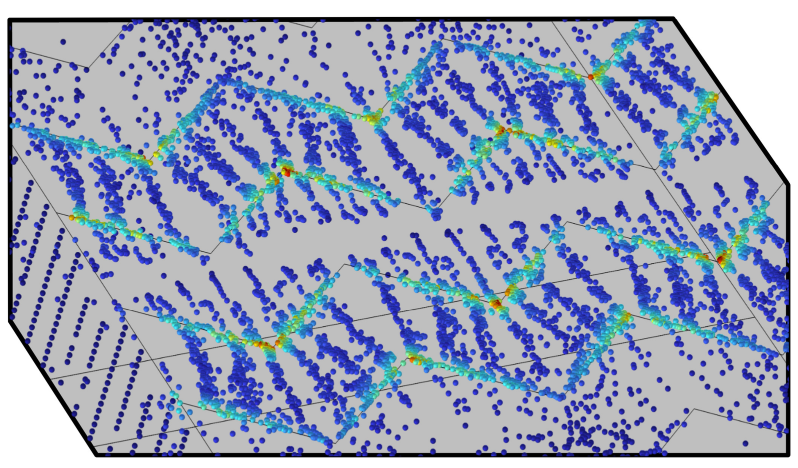


Figure 1. Results of simulation of DEP. Shown are particles captured by DEP. The particles color scheme indicates the force strength effecting the particles. Red illustrates high forces and blue illustrates low forces induced by DEP.

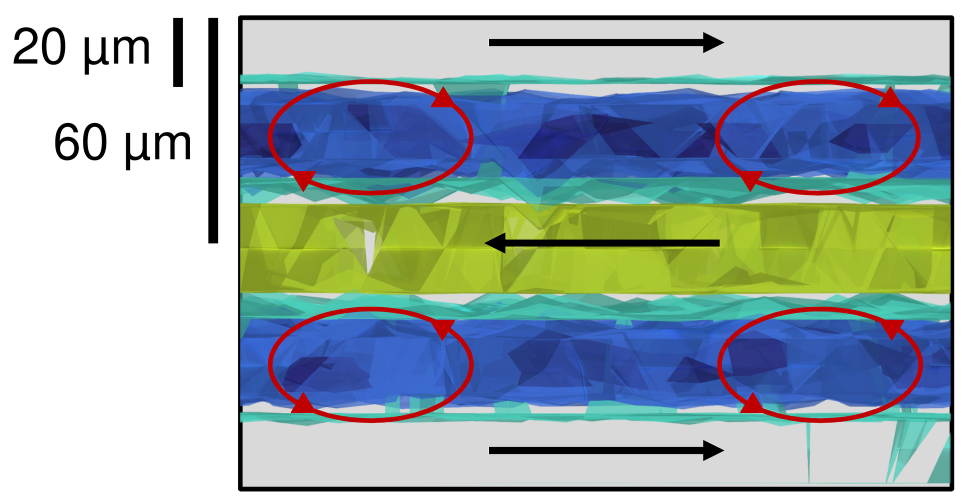


Figure 2. Fluid flow in the moment of change in direction. Gray and green areas represent a high absolute flow speed, while dark blue coloring indicates low flow speed. Black Arrows indicate direction of flow and red circular arrows imply turbulences.

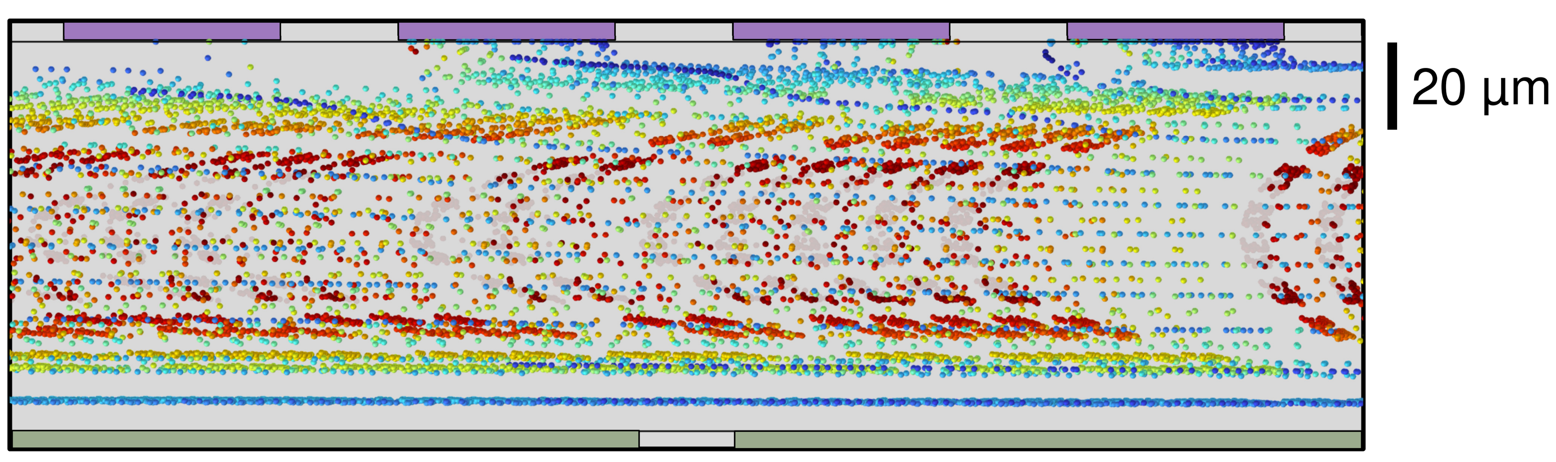


Figure 3. Particles effected by fluid flow and DEP force. Maximum fluid flow speed is 1.3 mm/s while particle flow speed is indicated by coloring. Red particles represent high speeds and blue particles low speeds.

The undisturbed DEP simulation displayed in **Figure 1** illustrates the pattern in which particles are captured. As this simulation did not include movement retarding factors, like resistance of the liquid, the effected radius well exceeds the simulated area. If those interactions are taken into consider-ation the effected area reduces significantly in size. This effect can be seen in **Figure 3** where most particles stay unaffected by the induced DEP force.

Based on the simulation of the interaction of fluid flow and DEP, shown in **Figure 3,** particles within 20 µm proximity to the DEP electrodes are captured by DEP. To enlarge this distance, oscillations of the fluid flow are utilized as shown in **Figure 2.** Due to the neighboring flow directions, circulations accrue which transport particles towards the effective area. Hence particles within 60 µm proximity to DEP electrodes can be attracted by DEP.

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