MATHEMATICAL MODELING OF AC ELECTROOSMOSIS IN MICROCHANNELS WITH CO-PLANAR AND 3D MICROELECTRODES

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A new type of electroosmotic micropumps has been recently reported [1]. These micropumps are driven by a low amplitude AC electric field imposed on systems of co-planar or more complex electrodes. It was found that the net velocity attained in microchannels can increase up to several hundreds microns per second [2]. Hence, the AC electroosmotic micropumps have a high potential in microfluidic applications, e.g., for sample dosing, electrolyte transportation, mixing on a microscale etc.

Moreover, interesting non-linear phenomena have been observed in experimental parametrical studies [3]. The direction of the net velocity depends on the AC electric field frequency, the microchannel geometry and other parameters. Any relevant explanation of the flow reversals in the parametric space has not been found.

In this contribution, we present a non-equilibrium mathematical model describing transport processes in microfluidic systems that contain coplanar and 3D electrodes. The mathematical model is based on balances of mass, momentum, and electric charge and non-slip boundary conditions. Because extremely thin electric double layers are formed within the system, a structured mesh combining the rectangle and the triangle finite elements had to be developed.

Effects of various model parameters such as geometric properties, the electrolyte concentration, and the AC frequency on the averaged net velocity in microchannels are discussed. Regimes suitable for the use in real microfluidic pumps are identified. Because the mathematical model describes the transport processes in the entire spatial and time domains, we are able to search for the possible origin of the flow reversals.

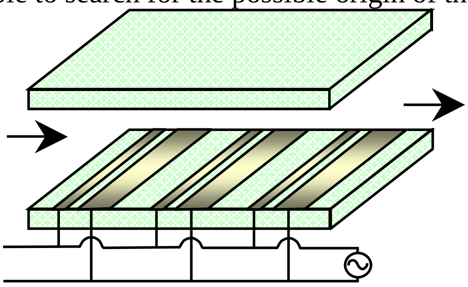

Figure 1: Scheme of co-planar microelectrodes

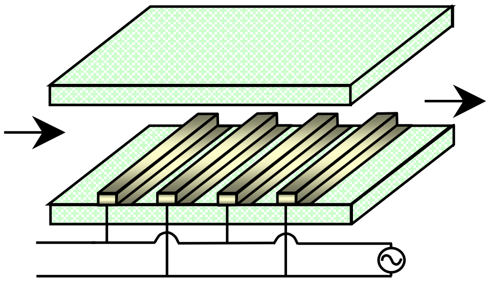

Figure 2: Scheme of three-dimensional microelectrodes

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