Numerical simulation of Dielectrophoresis and AC Electroosmosis for DNA trapping including the particle steric effect

Neophytos Loucaides[1], Antonio Ramos[2], George E. Georghiou[3]
[1,3]University of Cyprus, Department of Electrical and Computer Engineering, 75 Kallipoleos Str., Nicosia, Cyprus
[2]University of Seville, Department of Electronics and Electromagnetism, Faculty of Physics, 41012 Avenida Reina Mercedes, Sevilla, Spain
[1]eep4nl1@ucy.ac.cy

Dielectrophoresis (DEP) is a very promising method for nanoparticle manipulation [1]. It has already been used in order to trap, separate or manipulate many types of nanoparticles, such as DNA [2], carbon nanotubes [3], viruses [4] and many more. Nanoparticle dielectrophoresis is usually performed in microfluidic channels above electrode formations that induce an AC electric field. However, the process is very complex due to the interactions between the fluid, the particles and the electric field [5].

A physical model is presented here that includes the AC electroosmotic motion of the fluid, the dielectrophoretic force [6], the steric effect on the particle concentration [7] and on the fluid motion, as well as other parameters affecting the system (such as buoyancy, gravity, drag etc). This model, which is solved by the finite element method, is considered as the most complete to date for the characterisation and understanding of the processes encountered in such devices.

Results are presented for the specific case of the dielectrophoretic trapping of 12kb pTA250 DNA using parallel electrodes. The numerical predictions are subsequently compared with experimental results, demonstrating qualitative agreement with many observations. Furthermore, this model allows the investigation of device parameters which are very difficult or impossible to study under experimental conditions and provides new insights into the operation of such systems.

References:

[1] Hughes MP. Nanotechnology. **11**(2000):124-132.

[2] Bakewell DJ, Ermolina I, Morgan H, Milner J, Feldman Y. Biochimica et Biophysica Acta. **1493**(2000):151-158.

[3] Dimaki M, Boggild P. **15**(2004):1095-1102.

[4] Hughes MP, Morgan H. 21stAnnual International Conference of the IEEE Engineering in Medicine and Biology Society. Atlanta; 1999.

[5] Ramos A, Morgan H, Green NG, Castellanos A. J Phys D. **31(**1998): 2338-2353.

[6] Loucaides N, Georghiou GE, Charalambous CD. J Phys: Conf Ser.**61(**2007): 718-723.

[7] Kumar A, Qiu Z, Acrivos A, Khusid B, Jacqmin D. Phys Rev E.69(2004):021402.

Figures:

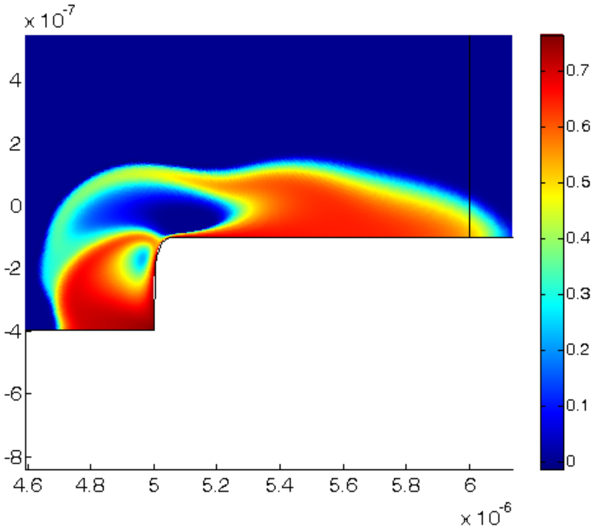

Figure 1. Steady state concentration over the electrode edge for 12kb pTA250 DNA under Dielectrophoresis and ACEO.