The Dolomite Centre Ltd
Unit 1, Anglian Business Park, Orchard Road,
Royston, Hertfordshire, SG8 5TW, UK
T: +44 (0)1763 242491
F: +44 (0)1763 246125
E: sales@dolomite-microfluidics.com
W: www.dolomite-microfluidics.com

Dolomite Microfluidics – North America Office
Blacktrace Inc, 29 Albion Place
Charlestown, MA 02129, USA
C: 617 803 6655
T: 617 848 1211
F: 617 500 0136
E: salesus@dolomite-microfluidics.com

Field-amplified sample stacking and focusing in nanofluidic channels

Jess M. Sustarich • Brian D. Storey • Sumita Pennathur

Abstract

Nanofluidic technology is gaining popularity for bioanalytical applications due to advances in both nanofabrication and design. One major obstacle in the widespread adoption of such technology for bioanalytical systems is efficient detection of samples due to the inherently low analyte concentrations present in such systems. This problem is exacerbated by the push for electronic detection, which requires an even higher sensor-local sample concentration than optical detection.

This paper explores one of the most common preconcentration techniques, field-amplified sample stacking, in nanofluidic systems in efforts to alleviate this obstacle. Holding the ratio of background electrolyte concentrations constant, the parameters of channel height, strength of electric field, and concentration are varied. Although in micron scale systems, these parameters have little or no effect on the final concentration enhancement achieved, nanofluidic experiments show strong dependencies on each of these parameters. Further, nanofluidic systems demonstrate an increased concentration enhancement over what is predicted and realized in microscale counterparts.

Accordingly, a depth-averaged theoretical model is developed that explains these observations and furthermore predicts a novel focusing mechanism that can explain the increased concentration enhancement achieved. Specifically, when the electric double layer is sufficient in size relative to the channel height, negatively charged analyte ions are repelled from negatively charged walls, and thus prefer to inhabit the centerline of the channels. The resulting induced pressure gradients formed due to the high and low electrical conductivity fluids in the channel force the ions to move at a slower velocity in the low-conductivity region, and a faster velocity in the high-conductivity region, leading to focusing. A simple single-channel model is capable of predicting key experimental observations, while a model that incorporates the details of the fluid inlet and outlet ports allows for more detailed comparisons between model and experiment.

For further information please refer to research paper Physics of Fluids 22, 112003 (2010)