Passive micro-pump

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Microfluidic devices are widely used in many applications in the industry. In these devices flow generation and control in the micro-channels remains a challenging task. Different techniques are being used for flow generation and control. These techniques include mechanical pumping and electrokinetic methods. In all these methods the device needs to be interfaced with outside world. This can be a serious drawback in many applications such as in targeted drug delivery and implanted sensors.

We have recently discovered a method for passive flow generation [1,2]. This flow is strongly associated with the phenomenon of solute free 'exclusion zone' that exists next to hydrophilic surfaces, which discovered by Jerry Pollack from University of Washington, in Seattle. Pollack and his team observed that when a hydrophilic surface comes into contact with an aqueous solution a solute free exclusion zone is formed next to the surface, which extends to hundreds of micrometers. Electric double layer theory, which explains the interaction between a charged surface and a surrounding solution, predicts that the effect of a charged surface will be completely shielded by presence of counter ions after a distance of a few tens of nanometers away from the surface. The reason for this very long interaction between the surface and its surrounding is still not well understood. In our lab we have observed that the formation of exclusion zone is always associated with generation of flow vortices that form next to the charged surface. This flow could continue for several hours without the need to apply voltage, pressure or temperature gradient. This flow could be utilized as a passive micro-pump to generate flow in micro-channels. In Figure 1 an optical microscope image shows micro-beads being driven by the passive micro-pump. This technique has great potential for dynamically manipulating micro-fluid flows, functioning as a micro-pump or mixer, especially for applications where the interface with the outside world is not possible.

In this project we would like to further study this flow to understand it and come up a method to optimize this flow in a micro-channel. We will use particle image velocimetry (micro-PIV) to study the flow. The work also involves design and fabrication of micro-fluidic channels which will be used for flow optimization. The work involves extensive experimental work and will be conducted using our miro-PIV setup and the micro-fabrication lab.

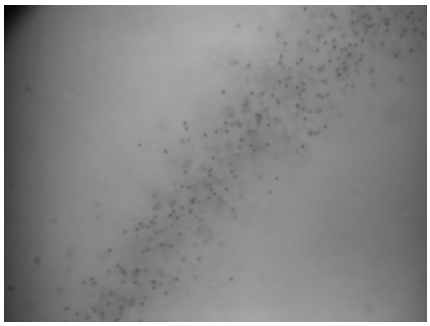

Figure 1: An optical microscope image showing beads being driven by passive micro-pump

References:

1. Sami Musa et al. "flow patterns induced by hydrophilic surfaces," Submitted to Phys. Rev. E., 2013.
2. Sami Musa et al. "Interfacial water: unexplained phenomena," Biot conference, Vienna, 2013.