DIELECTROPHORETIC SEPARATION OF COLLOIDAL PARTICLES USING ANGLED ELECTRODE ARRAY

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ABSTRACT

This paper presents a device developed for continuous flow-through dielectrophoretic separation of particles using microelectrode arrays. The device operates using angled electrodes and negative dielectrophoresis, achieving 100% spatial, contactless separation at the end of the array. Separation is demonstrated using a range of colloidal particles.

KEYWORDS: Dielectrophoresis, particle separation, microfluidics

INTRODUCTION

Dielectrophoretic separation has previously been demonstrated as a batch mode or a stop flow separation method. Generally, planar microelectrode arrays embedded in microfluidic channels or chambers are used to separate particles using a combination of positive and negative dielectrophoresis [1]. The behaviour of a particular particle type is frequency dependent and can change from positive to negative dielectrophoresis by changing the frequency. Electrode arrays can therefore be designed to separate particles exhibiting the two different behaviours to different positions by correct frequency selection. Positive dielectrophoresis, however, has the drawback that particles will collect on and stick to the electrodes. Negative dielectrophoresis, on the other repels particles from electrodes and gives the benefit of contact free particle handling [2]. This has led to the development of batch separation methods such as negative dielectrophoretic field flow fractionation [3]. This method, however, relies on gravity to achieve separation and separation of colloidal particles is therefore not possible due to the negligible influence of gravity.

EXPERIMENTAL

The device consists of V-shaped interdigitated electrode arrays on top and bottom of a microfluidic channel of width 500 microns and height 40 microns. The electrode width and spacing were 20 microns. The fabrication of this device has been reported previously [4] and a schematic diagram is shown in Figure 1. A range of fluorescently labelled latex spheres (Molecular Probes, USA) were used to test the device. Signals were generated using a TTI signal generator and amplifier.

RESULTS AND DISCUSSION

Figure 1 shows video frames collected at the input and output of the array. At the input, the sample stream enters the electrode array using hydrodynamic focussing to position it to one side of the microfluidic channel (Figure 1 (a)). Figure 1 (b) and (c)

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show frames from the ouput of the array demonstrating spatial separation of different sizes of latex spheres. The video data was then analysed by detecting the particles, measuring total intensity and plotting against position across the channel. The results for the separation of 500 nm and 1µm radius particles are shown in Figure 2 for 1MHz signals at a range of voltages. The separation between the two populations of particles (intensity giving size) can be seen clearly.

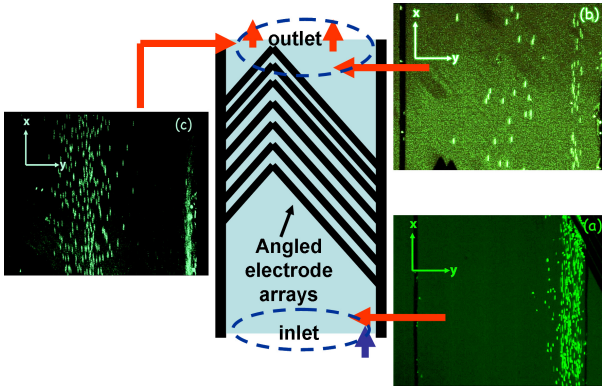

Figure 1. Schematic diagram of the electrode array and captured video images of the operation. (a) mix of particles hydrodynamically focussed at the inlet, (b) (b) 100% spatial separation of 1µm and 500nm radius particles at the outlet and (c) 100% spatial separation of 500nm and 250nm radius particles at the outlet.

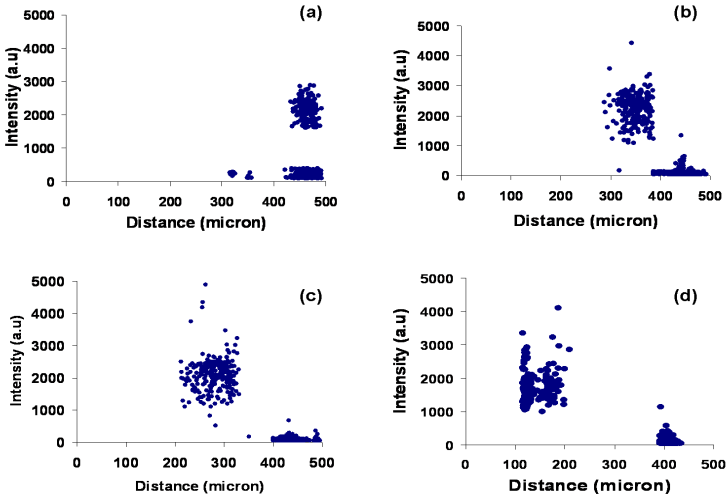

Figure 2. Graphs of the intensity versus distance across the channel width viewed at the end of the array. Medium conductivity was 14.8mS/m and the signal was 1MHz with voltages of (a) 1V (b) 7V (c) 7.5V and (d) 8.5V.

The separation distance between the two populations was then measured. Figure 3 shows the plot of the separation between 1µm and 500nm particles with increasing voltage in two different medium conductivities: 1.9mS/m and 14.8mS/m.

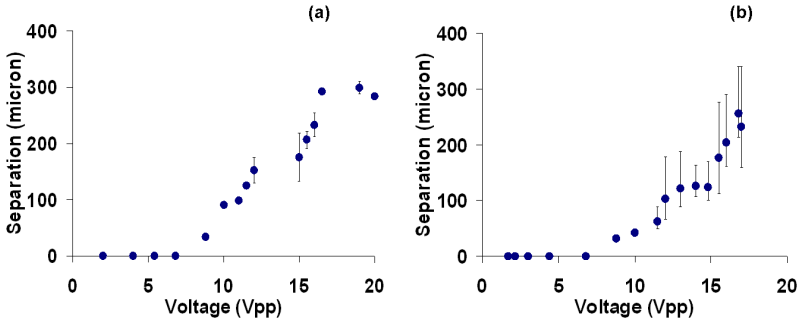

Figure 3. Separation distance between 1μm and 500nm particles vs voltage applied at 1MHz in medium conductivity of (a) 1.9mS/m and (b) 14.8mS/m.

In the higher conductivity, the particle separation was greater for the same voltage, in line with the theory that indicates that negative dielectrophoresis would be stronger. The results consistently demonstrated 100% spatial separation at the end of the array.

CONCLUSIONS

We have designed and constructed a microfluidic chip, which efficiently separated mixtures of two sizes of particles with similar dielectric permittivity. The intensities of the size of the particle versus distance across the channel were plotted demonstrating 100% spatial separation in a range of conductivities. One advantage of this separation method will work at high conductivities where only negative dielectrophoresis occurs. The separation of smaller particles should be possible with the application of higher field frequencies and also with devices of reduced geometry.

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