Popular science article

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Expanding our knowledge on particle separation using acoustic waves to improve its throughput

Microfluidics is the use of small channels to control small volumes of fluids. At the microscale, the fluid behaviour is predictable which is an advantage when you want a precise control of the fluids. Acoustophoresis means the use of sound waves to handle cells and particles in a microfluidic channel. With acoustophoresis we can separate a cell type from another based on their properties such as density or compressibility. We exploit channel resonance by placing transducers on the channel wall. We build up a strong acoustic field that results in lateral forces. The forces induce motion and the speed of the particle depends on its mechanical properties. Thus, it is possible to separate slow particles from fast particles. The fastest particles or cells will move closer to the center of the channel. By placing two outlets, one in the center of the channel, one on the sides, the particles will be separated by exiting through different outlets. An application of such system is to isolate rare cells. Only one to ten circulating tumor cells (CTCs) can be found in one milliliter of blood from a patient with metastatic disease. In comparison, there are millions of white blood cells and billions of red blood cells in one milliliter of blood. To isolate the CTCs, a large volume of sample needs to be processed. The throughput of the chip needs to be improved to have the sample processed in a reasonable amount of time, which means minutes, not hours. A logical step to increase the throughput is to increase the total flow rate. However, increasing the flow rate induces the spillover effect, all the particles exit through the center outlet and particle separation is impossible. By changing the flow rate ratios we succeeded to reduce the spillover effect and separation was obtained at a high flow rate of 1200 μL/min.

In some applications, the sample is diluted before processing which impacts the throughput of the chip. Separation needs to be achievable even at high concentration to not have to dilute the sample. When concentration is higher, particles are closer to each other and are more likely to interact with each others. The inter-particle interaction leads to hydrodynamic forces which deflect the particles trajectories. Indeed, we showed that for higher concentrations the particles are more focused towards the center of the channel.

Depending on their difference in acoustic properties, some cells or particles will be separated from each other more easily than others. In order to quantify this difference of mobility, we use the mobility ratio. It can be measured using methods such as particle tracking, but this method is time consuming and analyses the cells individually. By using particle separation, we tested a new and faster method to measure the mobility ratio which gives similar results to particle tracking.

The thesis presents new leads on how to improve particle separation and highlights the limitations that can be encountered when processing at high throughput.