Student Paper

Separation of biological cells using surface acoustic waves depending on compressibility with a new structure

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Microfluidic technology plays an important role in manipulation of microparticles. In the two last decades researchers had studies and experimental researches on manipulation of particles in different methods such as DEP , optical , acoustophoresis , etc. In this study we have focused on acoustic technology . Acoustic force may be used for particle manipulation specially separation of particles using high intensity sound waves. Piezoelectricity was discovered in 1880 by French physicists Jacques and Pierre Curie , which explained how a piezoelectric material such as quartz , LiNbO3 translate one form of energy to another. The nature of the piezoelectric effect is closely related to the occurrence of electric dipole moments in solids. An electric potential leads to deformation of material and reversely.Using this effect we can design devices to manipulate particles. In recent years very few methods have used compressibility of mixed solid particles in a liquid for purification , sorting , focusing , separation , etc. Our method is an advancement way within acoustophoretic separation of biological cells, as the ability to differ from compressibility of the cells. Standing surface acoustic waves (SSAW) generated by combining two waves with same magnitudes and difference phase of 180-degree. When two waves come together make an standing surface acoustic wave involving pressure nodes and anti-pressure nodes. In pressure nodes , wave has minimum changes ,while anti-pressure nodes have maximum changes. According to theoretical acoustics, each particle exposing a standing surface acoustic wave tend to reach pressure or anti-pressure node depending its physical properties. In an SSAW field, particles experience two kinds of acoustic forces : primary acoustic force (PRF) and secondary acoustic force (SCF) , that expressed as follow :

$$F_{AXi} = -V_p . E_{ac} . k . \Phi . \sin(2kx)$$

$$\Phi = \left(\frac{3(\rho_p - \rho_m)}{\rho_m + 2\rho_p} + \frac{\beta_m - \beta_p}{\beta_m} \right)$$

$$F_{sec} = 4\pi a^2 \left\{ \frac{(\rho_p - \rho_m)^2 (3cos^2(\theta) - 1)}{6\rho_m d^4} v^2(x) - \frac{\omega^2 \rho_m (\beta_p - \beta_m)^2}{9d^2} p^2(x) \right\}$$

Where V_p , E_{ac} , k , φ , β , ρ are particle volume , acoustic energy density , wave number , contrast factor , compressibility and density ,respectively; m denotes the media and p denotes the particle; Φ is a determination factor , because particle with positive contrast factor reach the pressure nodes and negative contrast factor push them to the anti-pressure nodes. By this fact we have studied on the compressibility of two particles with different compressibility resulting various contrast factor and separated them.

Separation mechanism :

In this study we need IDTs (Inter Digital Transducers) , SFIT(Slanted Finger Interdigital Transducer), and the substrate made of LiNbO3 . IDTs and SFITs are generated by the lithography process and patterned on the substrate . The width and length of the microchannel are calculated. A microchannel was positioned and bonded between IDTs and SFITs. Positioning and localization of transducers depends on the width of the microchannel. The sample particles are biological cells : WBCs(White Blood Cells) and a kind of cancer cell, which are different as compressibility. The microchannel has an inlet and three outlets. A mixture solution of the particles was injected through the side inlets . We don't need any sheath flow because a pair of IDT in the first part of channel align particles in a line . When particles injected through the inlet after a few seconds experience SSAW field, if IDTs placed in the suitable places particle can reach pressure node in the middle of the microchannel. Also a pair of SFIT localize in the second part of the channel as shown in the figure1. Because SFIT is tapered shape help us to tune the SSAW, so the exact place of particle concentration can be reached. It is a key point of our work . In the previous studies, to separate particle using standing surface acoustic wave, the results show that percentage of separation in more cases isn't sufficient. But our study shows good results compared with recent papers. This method features easy fabrication and handling, low cost, and rapid response time. This model has been simulated with COMSOL.MULTIPHYSICS 4.3a using acoustics , laminar flow and particle tracing physics.

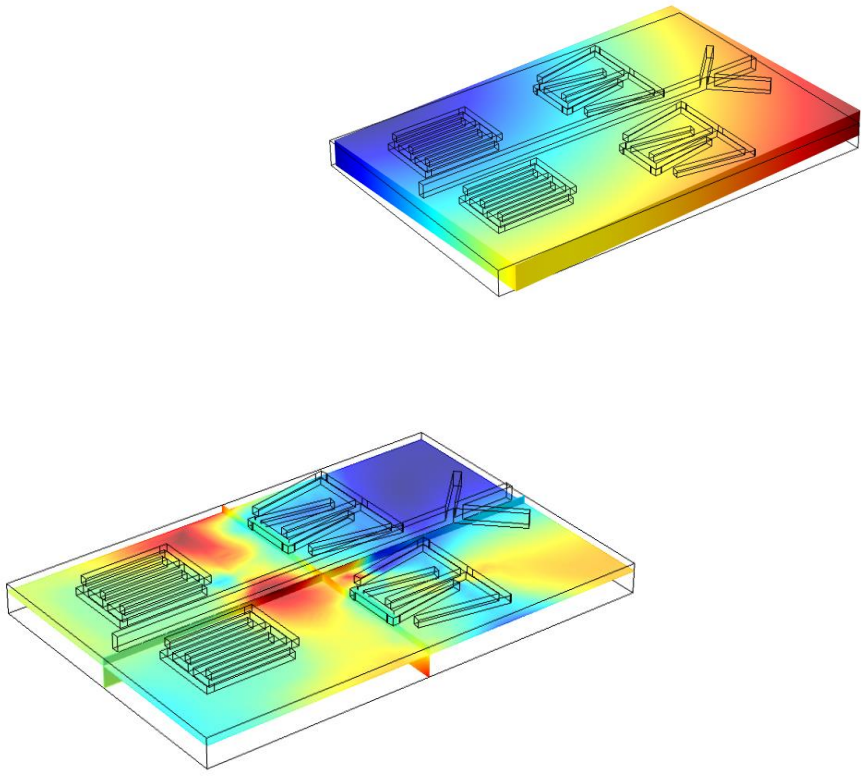

Figure 1 " schematics of simulation result"

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