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Multi-Size Continuous Particle Separation on a Dielectrophoresis-Based Microfluidics Chip

Authors : Arash Dalili, Hamed Tahmouressi, Mina Hoorfar

Abstract : Advances in lab-on-a-chip (LOC) devices have led to significant advances in the manipulation, separation, and isolation of particles and cells. Among the different active and passive particle manipulation methods, dielectrophoresis (DEP) has been proven to be a versatile mechanism as it is label-free, cost-effective, simple to operate, and has high manipulation efficiency. DEP has been applied for a wide range of biological and environmental applications. A popular form of DEP devices is the continuous manipulation of particles by using co-planar slanted electrodes, which utilizes a sheath flow to focus the particles into one side of the microchannel. When particles enter the DEP manipulation zone, the negative DEP (nDEP) force generated by the slanted electrodes deflects the particles laterally towards the opposite side of the microchannel. The lateral displacement of the particles is dependent on multiple parameters including the geometry of the electrodes, the width, length and height of the microchannel, the size of the particles and the throughput. In this study, COMSOL Multiphysics® modeling along with experimental studies are used to investigate the effect of the aforementioned parameters. The electric field between the electrodes and the induced DEP force on the particles are modelled by COMSOL Multiphysics®. The simulation model is used to show the effect of the DEP force on the particles, and how the geometry of the electrodes (width of the electrodes and the gap between them) plays a role in the manipulation of polystyrene microparticles. The simulation results show that increasing the electrode width to a certain limit, which depends on the height of the channel, increases the induced DEP force. Also, decreasing the gap between the electrodes leads to a stronger DEP force. Based on these results, criteria for the fabrication of the electrodes were found, and soft lithography was used to fabricate interdigitated slanted electrodes and microchannels. Experimental studies were run to find the effect of the flow rate, geometrical parameters of the microchannel such as length, width, and height as well as the electrodes' angle on the displacement of 5 um, 10 um and 15 um polystyrene particles. An empirical equation is developed to predict the displacement of the particles under different conditions. It is shown that the displacement of the particles is more for longer and lower height channels, lower flow rates, and bigger particles. On the other hand, the effect of the angle of the electrodes on the displacement of the particles was negligible. Based on the results, we have developed an optimum design (in terms of efficiency and throughput) for three size separation of particles.

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