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Particle Gradient Generation in a Microchannel Using a Single IDT

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Abstract : Standing surface acoustic waves (sSAWs) have already been used to manipulate particles in a microfluidic channel made of polydimethylsiloxan (PDMS). Usually two identical facing interdigital transducers (IDTs) are exploited to form an sSAW. Further, it has been reported that an sSAW can be generated by a single IDT using a superstrate resonating cavity or a PDMS post. Nevertheless, both setups utilising a traveling surface acoustic wave (tSAW) to create an sSAW for particle manipulation are costly. We present a simplified setup with a tSAW and a PDMS channel to form an sSAW. The incident tSAW is reflected at the rear PDMS channel wall and superimposed with the reflected tSAW. This superpositioned waves generates an sSAW but only at regions where the distance to the rear channel wall is smaller as the attenuation length of the tSAW minus the channel width. Therefore in a channel of 500µm width a tSAW with a wavelength λ = 120 µm causes a sSAW over the whole channel, whereas a tSAW with λ = 60 µm only forms an sSAW next to the rear wall of the channel, taken into account the attenuation length of a tSAW in water. Hence, it is possible to concentrate and trap particles in a defined region of the channel by adjusting the relation between the channel width and tSAW wavelength. Moreover, it is possible to generate a particle gradient over the channel width by picking the right ratio between channel wall and wavelength. The particles are moved towards the rear wall by the acoustic streaming force (ASF) and the acoustic radiation force (ARF) caused by the tSAW generated bulk acoustic wave (BAW). At regions in the channel were the sSAW is dominating the ARF focuses the particles in the pressure nodes formed by the sSAW caused BAW. On the one side the ARF generated by the sSAW traps the particle at the center of the tSAW beam, i. e. of the IDT aperture. On the other side, the ASF leads to two vortices, one on the left and on the right side of the focus region, deflecting the particles out of it. Through variation of the applied power it is possible to vary the number of particles trapped in the focus points, because near to the rear wall the amplitude of the reflected tSAW is higher and, therefore, the ARF of the sSAW is stronger. So in the vicinity of the rear wall the concentration of particles is higher but decreases with increasing distance to the wall, forming a gradient of particles. The particle gradient depends on the applied power as well as on the flow rate. Thus by variation of these two parameters it is possible to change the particle gradient. Furthermore, we show that the particle gradient can be modified by changing the relation between the channel width and tSAW wavelength. Concluding a single IDT generates an sSAW in a PDMS microchannel enables particle gradient generation in a well-defined microfluidic flow system utilising the ARF and ASF of a tSAW and an sSAW.

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