

EFFECT OF FLUID FLOW RATE ON PARTICLE FILTRATION AND TRAPPING THROUGH MICROFLUIDICS BASED PILLAR MICROFLITERS

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The field of microfluidics has become an attractive and promising research area for wide range of applications. Concepts of point of care diagnostics, lab-on-chip, micro-total-analytical-systems (μ -TAS) in microfluidics for efficient drug delivery, diagnostics, body-fluid analysis, digital logic generation, droplet generation, mixing, cell sorting, separation, counting of cells and much more; Inherent laminar nature of fluid flow through microchannel makes possibilities for separation of fluid particulate components. Separation of particles or biological cells is an important aspect of medical research in diagnosing diseases and finding remedies. Physical microfilters have been reported as a method of obtaining label free and high filtration efficiency for particle separation [1,2]. Microfluidics devices tend to have extensive network of microfilters to enhance the overall throughput of filtration. However, this also causes increased pressure drop through microchannel networks resulting in formation of recirculation and stagnation zones. A flow rate dependent study is provided here. A pillar filter network is simulated at different flow velocities and stagnation zones are visualised.

Passive microfilters based microfluidic channel is designed and simulated using COMSOL multiphysics software (figure 1). Flow dependent stagnation zones are studies using simulation and flow experiments. At low flow rates (~ 0.1 ml/hour) the flow velocity across middle zone of the microchannels was found to be low (thus forming low filtration zone), which is further experimentally verified. A PDMS based microchannel with pillar filter is fabricated using standard microelectronics unit processes. Solution of Polystyrene microbeads of $5\mu\text{m}$ diameter was used to assess the effect of flow rates on the filtration performance of microfiltration device (figure 2). Set of flow rates i.e., 0.1 ml/hour, 1 ml/hour, 5 ml/hour and 10 ml/hour was used to flow sample through the channel. High resolution optical videos are captured and fluid flow is visualised. Number of stagnant filters reduced with increase in flow rate. This study can be used to optimize physical filters in microfluidics platforms.

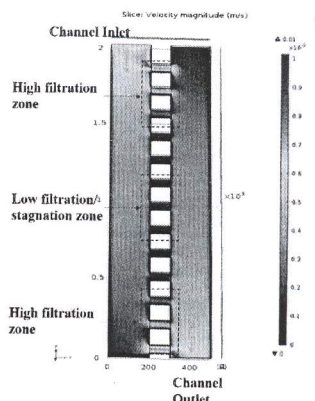


Figure 1: Surface plot of velocity profile of simulated pillar microfilters design

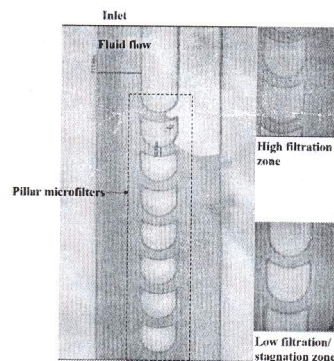


Figure 2: Polystyrene bead ($5\mu\text{m}$ diameter) solution flow at different flow rates through microfluidics pillar filter channel

References

- [1] Ji, Hong Miao, et al. "Silicon-based microfilters for whole blood cell separation." *Biomedical microdevices* 10.2 (2008): 251-257..
- [2] Tang, Yadong, et al. "Microfluidic device with integrated microfilter of conical-shaped holes for high efficiency and high purity capture of circulating tumor cells." *Scientific reports* 4 (2014).

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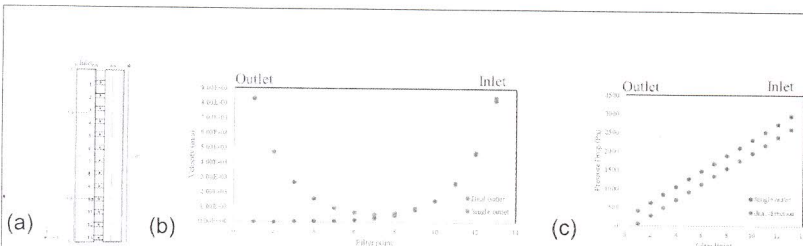
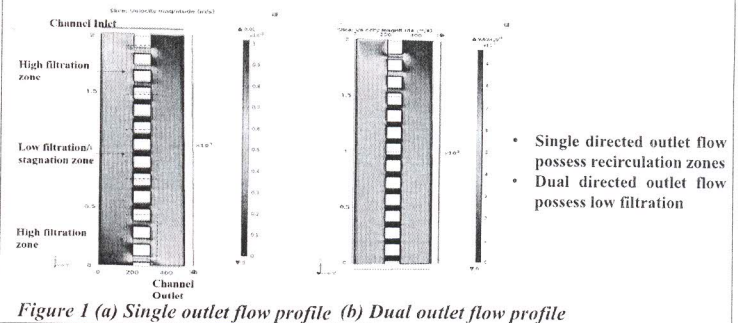
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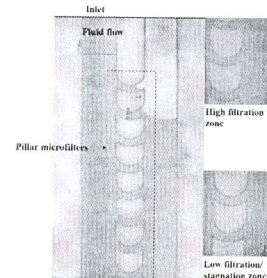
Introduction

1. Separation of particles or biological cells is an important aspect of medical research and diagnostics.
2. Physical micro-filters are reported as a method label free method with high filtration efficiency for particle separation[1], but also cause excessive pressure drop for filtration.
3. A flow rate dependent study is provided with simulated pillar filter network and experimental investigation of flow rate dependent filtration and stagnation zones.

Simulation Results



Experimental Results



Optical Characterization

Flow rate (ml/hour)	0.1	0.3	0.5	1	5
Position of filters					
Near Inlet					
Middle					
Near Outlet					

Figure 4 Optical images of filter sections near inlet, middle of channel and near outlet of the channel. Solution of diluted particles is used to assess the effect of flow rates on the filtration performance of microfiltration device. Particle with high velocity appears as a streak and with low velocity appears as small dots. In middle section of the pillar filter channel the particle velocity is found to be least.

Conclusions

- Passive micro-filters based microfluidic channel is designed and simulated using COMSOL multiphysics software (figure 1-2).
- Flow dependent stagnation zones are studied using simulation and flow experiments.
- A PDMS based microchannel with pillar filter is fabricated using standard microelectronics unit processes.
- At low flow rates (~0.1ml/hour) the flow velocity across middle zone of the microchannels was found to be low (thus forming low filtration zone).
- Number of stagnant filters reduced with increase in flow rate.
- This study can be used to optimize physical filters in microfluidics platforms.

References

1. Tang, Yadong, et al. "Microfluidic device with integrated microfilter of conical-shaped holes for high efficiency and high purity capture of circulating tumor cells." Scientific reports 4 (2014).

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