World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:13, No:07, 2019

Microfluidic Fluid Shear Mechanotransduction Device Using Linear Optimization of Hydraulic Channels

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Abstract : A logarithmic microfluidic shear device was designed and fabricated for cellular mechanotransduction studies. The device contains four cell culture chambers in which flow was modulated to achieve a logarithmic increment. Resistance values were optimized to make the device compact. The network of resistances was developed according to a unique combination of series and parallel resistances as found via optimization. Simulation results done in Ansys 16.1 matched the analytical calculations and showed the shear stress distribution at different inlet flow rates. Fabrication of the device was carried out using conventional photolithography and PDMS soft lithography. Flow profile was validated taking DI water as working fluid and measuring the volume collected at all four outlets. Volumes collected at the outlets were in accordance with the simulation results at inlet flow rates ranging from 1 ml/min to 0.1 ml/min. The device can exert fluid shear stresses ranging four orders of magnitude on the culture chamber walls which will cover shear stress values from interstitial flow to blood flow. This will allow studying cell behavior in the long physiological range of shear stress in a single run reducing number of experiments.

Keywords : microfluidics, mechanotransduction, fluid shear stress, physiological shear
Conference Title : ICMN 2019 : International Conference on Microfluidics and Nanofluidics
Conference Location : Prague, Czechia
Conference Dates : July 09-10, 2019

Open Science Index, Biomedical and Biological Engineering Vol:13, No:07, 2019 publications.waset.org/abstracts/103189/pdf