World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:11, No:07, 2017

High Aspect Ratio Micropillar Array Based Microfluidic Viscometer

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Abstract : We present a new viscometer based on a microfluidic chip with elastic high aspect ratio micropillar arrays. The displacement of pillar tips in flow direction can be used to analyze viscosity of liquid. In our work, Computational Fluid Dynamics (CFD) is used to analyze pillar displacement of various micropillar array configurations in flow direction at different viscosities. Following CFD optimization, micro-CNC based rapid prototyping is used to fabricate molds for microfluidic chips. Microfluidic chips are fabricated out of polydimethylsiloxane (PDMS) using soft lithography methods with molds machined out of aluminum. Tip displacements of micropillar array (300 µm in diameter and 1400 µm in height) in flow direction are recorded using a microscope mounted camera, and the displacements are analyzed using image processing with an algorithm written in MATLAB. Experiments are performed with water-glycerol solutions mixed at 4 different ratios to attain 1 cP, 5 cP, 10 cP and 15 cP viscosities at room temperature. The prepared solutions are injected into the microfluidic chips using a syringe pump at flow rates from 10-100 mL / hr and the displacement versus flow rate is plotted for different viscosities. A displacement of around 1.5 µm was observed for 15 cP solution at 60 mL / hr while only a 1 µm displacement was observed for 10 cP solution. The presented viscometer design optimization is still in progress for better sensitivity and accuracy. Our microfluidic viscometer platform has potential for tailor made microfluidic chips to enable real time observation and control of viscosity changes in biological or chemical reactions.

Keywords : Computational Fluid Dynamics (CFD), high aspect ratio, micropillar array, viscometer
Conference Title : ICMN 2017 : International Conference on Microfluidics and Nanofluidics
Conference Location : Prague, Czechia
Conference Dates : July 09-10, 2017