Mechanical Engineering Master's Defense

An Experimental Investigation of Capillary Driven Flow in Open RectangularChannels: A Method to Create PDMS Microfilaments for pN Scale Force Measurements

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abstract

The flow of liquid PDMS (10:1 v/v base to cross-linker ratio) in open, rectangular silicon micro channels, with and without a hexa-methyl-di-silazane (HMDS) or poly-tetra-fluoro-ethylene (PTFE) (120 nm) coat, was studied. Photolithographic patterning and etching of silicon wafers was used to create micro channels with a range of widths (5-50 μm) and depths (5-20 μm). The experimental PDMS flow rates were compared to an analytical model based on the work of Lucas and Washburn. The experimental flow rates closely matched the predicted flow rates for channels with an aspect ratio (width to depth), p, between one and two. Flow rates in channels with p less than one were higher than predicted whereas the opposite was true for channels with p greater than two. The divergence between the experimental and predicted flow rates steadily increased with increasing p. These findings are rationalized in terms of the effect of channel dimensions on the front and top meniscus morphology and the possible deviation from the no-slip condition at the channel walls at high shear rates.

In addition, a preliminary experimental setup for calibration tests on ultrasensitive PDMS cantilever beams is reported. One loading and unloading cycle is completed on a microcantilever PDMS beam (theoretical stiffness 0.5 pN/ μm). Beam deflections are actuated by adjusting the buoyancy force on the beam, which is submerged in water, by the addition of heat. The expected loading and unloading curve is produced, albeit with significant noise. The experimental results indicate that the beam stiffness is a factor of six larger than predicted theoretically. One probable explanation is that the beam geometry may change when it is removed from the channel after curing, making assumptions about the beam geometry used in the theoretical analysis inaccurate. This theory is bolstered by experimental data discussed in the report. Other sources of error which could partially contribute to the divergent results are discussed. Improvements to the experimental setup for future work are suggested.

May 27, 2014; 3:00 PM; ENGRC 593