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Drag Reduction of Microchannels with Large Shear-Free Menisci on Opposing Partially Substrateless Walls

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Extended Abstract

The utilisation of superhydrophobic surfaces for the reduction of flow resistance has been the subject of increasing attention in the context of recent advances in micro- and nanotechnology [1]. One straightforward method to further improve the slip is to increase the gas fraction of the microchannel [2]. However, superhydrophobic structures are not without intrinsic limitations. The fragility of the intricate micro- or nano-scale components may result in lubricant abrasion or plastron depletion, leading to the elimination of the anticipated slip [3,4].

Initial investigations of a partially substrateless microchannel with one large continuous air/water meniscus maintained at atmospheric pressure and integrated in a hydrophobic wall demonstrated a maximum slip of 20 µm, despite a gas fraction of only 4% [5]. Consequently, further studies were conducted to investigate the potential for increasing the gas fraction on opposite sides of the microchannel. Thus, perforated walls were fabricated through dry DRIE etching of structured silicon wafers to create rectangular slits, followed by the bonding of OTCS (octadecyltrichlorosilane) to receive hydrophobic walls. These were installed as opposing walls of a partially substrateless microchannel with longitudinal air/water menisci maintained at atmospheric pressure.

During flow experiments evaluation of the spatially resolved static pressure was conducted using a white light interferometer. The optically determined pressure drop along the microchannel was measured independently for the opposing menisci and are in good agreement with the pressure sensor measurements. Furthermore, simulations were conducted taking the measured meniscus curvature as well as the realistic microchannel geometry into account. With the pressure drop evaluated from simulation data a slip length of 33 µm was received for the microchannel with a gas fraction of 6%.

References

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