SHEAR STRESS MEASUREMENTS BY OPTICAL TWEEZERS IN A MICROFLUIDIC DEVICE

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KEY WORDS: microfluidics, shear stress, optical tweezers, sensor

As more biological experiments are performed on microfluidic platforms, there is growing interest to develop localised and integrated sensors to study the microfluidic systems. In addition, shear stress study in microfluidics has been limited even though it is very important in cell biology. Here we present a method of shear stress measurement by optical tweezers in a microfluidic device. The sensor is able to perform highly localised detection at arbitrary positions in the device and characterise shear stress on microspheres of different sizes.

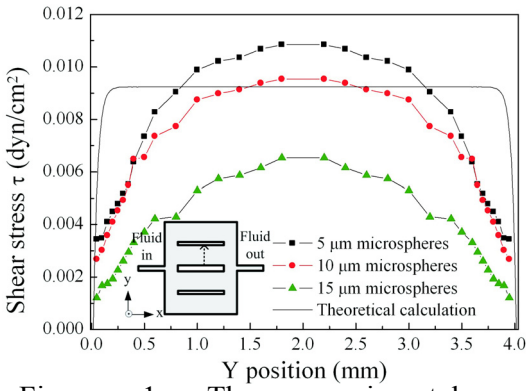

Figure 1. The experimental and calculated shear stress in a microfluidic device. The dashed line indicates the direction of the measurements.

The shear stress was characterised by measuring the threshold optical trapping force. The optical trapping force (F_t), Stokes force (F_{drag}) and shear stress (τ) are given by references [1-3] as

$$F_t = \frac{Q_t n_2 P}{c}, \quad (1)$$

$$F_{drag} \approx 6\pi\mu r \upsilon(1 + P_{b1}), \quad (2)$$

$$\tau = \mu \frac{\partial \upsilon}{\partial z}, \quad (3)$$

where Q_t is the trapping efficiency, n_2 is the refractive index of the water, P is the threshold laser power, c is the speed of light in a vacuum, μ is the viscosity coefficient of the water, r is the microsphere radius, υ is the fluid velocity, P_{b1} is the boundary correction parameter.

As shown in Fig. 1, the experimental shear stress is related to the microsphere size, with the maximum value at the channel center scaled down corresponding to the microsphere diameters.

In summary, we have demonstrated an optical tweezer sensor to characterise shear stress on microspheres of different sizes in a microfluidic device. Comparison of the experimental measurements with analytical calculations suggests that the microspheres size has an impact on the shear stress.

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