A Transparent Flow Velocity Sensor of Ultra-thin Glass Fabricated by Femtosecond Laser Processing

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Flow velocity measurement in microchannel is an important issue because the flow velocity plays a crucial role in flow cytometry and cell/particle sorting. Despite its importance, the performance is restricted by the limited space of microchannel. The conventional thermal sensor with heating might damage biological objects flowing in the microchannel. In addition, the mechanical sensor with complicated structures is difficult to fabricate and it is challenging to place the sensor at the desired position for velocity measurement [1-2]. In this study, we propose the development of a transparent and durable flow velocity sensor made of an ultra-thin glass sheet by femtosecond laser processing that is simple in structure and with less influence to flow in the microchannel.

The measurement system consists of a sensor and a laser detection system (Fig.1a). The proposed sensor is an ultra-thin glass sheet fabricated by femtosecond laser processing, which is integrated in microfluidic chip. The structure of the glass sheet is several rectangles with different areas, three sides are free and one side is fixed (Fig.1b). For flow velocity measurement, the reflected laser spot is located at the center of two-segmented photodiode (TSP) on the condition without flow in the microchannel. When there is flow in the microchannel, the reflected laser spot moves on the TSP with deformation of the sensor (Fig.1c). The temporal position shift of the laser spot is recorded to quantify the flow velocity. Vertically, the sensor is influenced by the combined effect of lift force, gravity and elastic force. The dynamic balance of these forces control the deflection and vibration of sensor (Fig.1d).

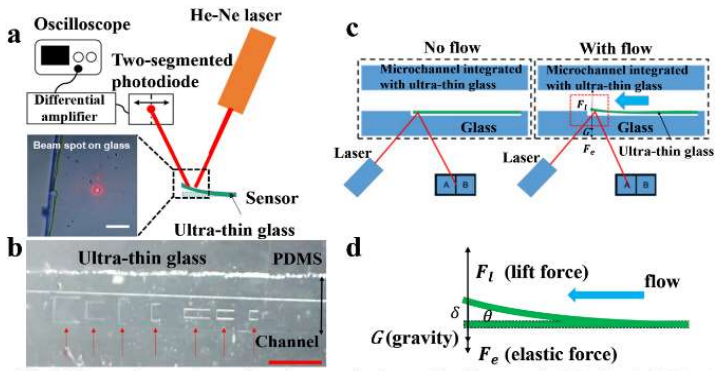

Fig.1 Measuring system, structure and schematic of sensor(scale bar in a, b:10,50μm)

In the experiment, we find an interesting phenomenon that the sensor vibrates periodically under the influence of flow and the vibration frequency increases with the increase of flow velocity in a specific range (0-300μl/min), as shown in Fig.2. In the following research, we will further analyze the force balance and attempt to understand the relationship of between flow velocity and vibration frequency of sensor. Moreover, multi-position measurement of flow velocity will also be explored.

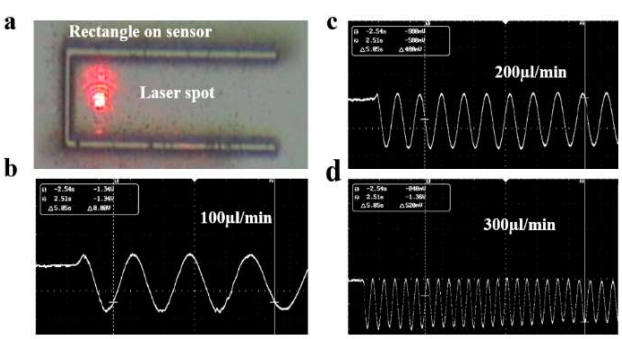

Fig.2 Experiment results of flow velocity measurement with vibration frequency

Reference

[1] Czaplewski, et al. J MICROELECTROMECH S, 2004, 13(4), 576-585. [2] Nezhad, et al. IEEE SENS J, 2012, 13(2), 601-609