A BI-DIRECTIONAL MICROFLUIDIC DRIVING SYSTEM

Chun-Ping Jen, Wei-Da Wu, Chung-Yi Wu, Yu-Cheng Lin, Guang-Guo Wu* and Chong-Ching Chang*
Department of Engineering Science, National Cheng Kung University, Tainan, Taiwan
*Department of Mechanical Engineering, Kun Shan University of Technology, Tainan, Taiwan

A bi-directional microfluidic driving system was developed either numerically and experimentally herein. This system provides a stable and flexible bi-directional microfluidic driving control. In biomedical applications, the µTAS method must be designed considering special transport mechanisms to move samples and reagents through the microchannels that connect the unit procedure components in the systems [1,2]. However, there is still a considerable technical challenge in integrating these procedures into a multiple-step system [3]. An important issue for this integration is a microfluid management technique, i.e. microfluid transportation, metering, and mixing. Flow–injection analysis provides a possibility to adjust samples or reagents to the given selectivity and dynamic range of the systems in use [4].

The pumping actuation is introduced to the microchannel fabricated in chip by blowing an airflow through this device. The bi-directional microfluid control module is composed of the suction and exclusion components [5]. The servo system includes an air compressor, a buffer tank and conduits for airflows. The airflow passes through the air gallery of the suction component with constriction, therefore, the individual suction component provides suction due to the Bernoulli's equation. The individual exclusion component produces exclusion through the pneumatic structure, which leads the airflow to the microchannel when the airflow passes through the air gallery of this component. A driving module with bi-directional pumping provides the net effect of suction or exclusion, which can be applied on the reaction chip for specific uses. After the individual components for suction and exclusion are implemented, the bi-directional driving module can be designed by combining the suction and exclusion component. The driving module with bi-direction microfluid pumping is illustrated in Figure 1. The individual components can be combined using a T-shape connection, which is shown in Fig. 1a. This connection is a simplest way, which can be designed by intuition. The individual components for suction and exclusion can also be connected in parallel, as illustrated in Figs. 1b-1d. The parallel connections of the individual components are designed as three cases. The width of the horizontal microchannels at the junction is 600 µm and the width of the vertical one is 300 µm in case 1 (Fig. 1b). The widths of both the horizontal and vertical microchannels are 600 µm in case 2 and 300 µm in case 3, respectively (shown in Fig. 1c-1d). The driving module is 600µm in depth. The channel size at the junction influences the flow field in the individual components and determines the net effect of suction or exclusion. The samples and reagents are in the control of the bi-directional driving module and perform biochemical assays in the reaction area. The samples and reagents in the reaction area can move forward, backward and stop under control by this driving module. For the working principle of this design, pumping is not straightforwardly induced by the pressure introduced by the air conduit but based on reliable physics caused by steady airflow. The velocity at the inlet channel can be adjusted by varying the inlet velocities for the suction and exclusion components. According to the numerical and experimental results, the flow fields in the driving module with the parallel connection exhibit a stable and linear relationship. The driving module was fabricated on PMMA, whose dimensions are shown in Figure 2.

According to the results in this investigation, the narrow microchannels at the junction synthesized the suction and exclusion effects and avoided the "crossalk" of the two individual components. The results indicated that operating range of the driving module with narrow microchannels at the junction was widest and the output velocities for this case exhibited good linearity for the application of specific biochemical analysis.

REFERENCES

[1] A. van den Berg, W. Olthuis, P. Bergveld (Eds.), Micro Total Analysis Systems 2000: Proceedings of the µTAS 2000 Symposium, Kluwer Academic Publisher.
[2] M. Elwenspoek, T. S. J. Lammerink, R. Miyake and J. H. J. Fluitman, J. Micromech. Microeng. 1994, 4, pp. 227-245.
[3] M. A. Burns, B. N. Johnson, S. N. Brahmasandra, K. Handique, J. R. Webster, M. Krishnan, T. S. Sammarco, P. D. T. Burke, Science 1998, 282, pp. 484-487.
[4] S. Shoji and M. Esashi, J. Micromech. Microeng. 1994, 4, pp. 157-171.
[5] C. P. Jen and Y. C. Lin, J. Micromech. Microeng. 2001 (accepted).

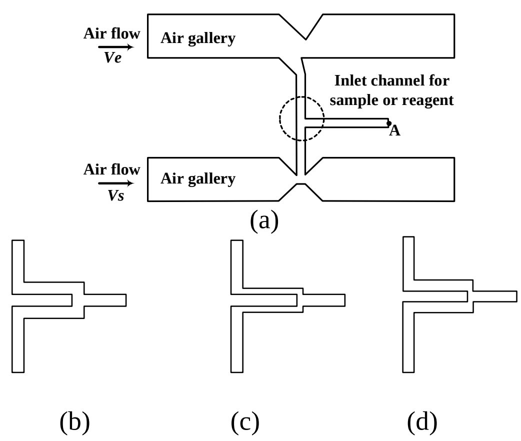

Figure 1. Schematic diagrams of the driving module: (a) T shape connection, (b-d) parallel connection in the dash line region of (a).

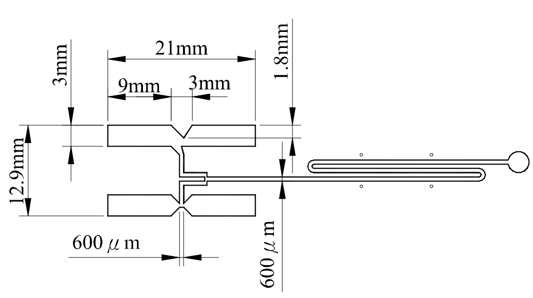

Figure 2. Dimensions of the driving module with a suction tendency connection, which used for the experiments.