DEVELOPMENT OF MICRO NEEDLE-HEAD SLIDE VALVE UNIT FOR MICROFLUIDIC DEVICES

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Abstract
A novel micro needle-head slide microvalve unit is presented. It is actuated by the micro stepping motor for microfluidic devices. The advantage of the design of this novel microvalve is to easily replace a micro needle-head and a various kinds of microactuator depending on users’ application. Its structure is very simple and compact. Its leakage test and stop flow test was demonstrated.

Keyword: micro slide valve, micro needle-head, microfluidics, micro stepping motor

1. Introduction
We have developed a novel micro needle-head slide microvalve actuated by micro stepping motor for microfluidic devices. There are a great demand for durable and robust microvalves for microfluidic devices [1]. The structure of our microvalve is very simple and compact. The mechanism of microvalve is very robust. The advantage of the design of this novel microvalve is to easily replace a micro needle-head and a various kinds of microactuator depending on users’ application. A microvalve unit and a microchip are also easily separated manually.

2. Device design and experiments
Figure 1 shows a schematic diagram of top and side view of two micro needle-head slidevalve units on a 70mmx30mm glass microchip we have developed. The diameter and height of a micro stepping motor is 5mm and 8mm. The size of total microvalve unit is 22mm x 14mm x 21.5mm. A microhole was drilled on a glass microchip where a micro needle-head was driven through up and down by a micro stepping motor. The diameter of a micro needle-head is 200μm. The micro needle-head was connected to a micro ball screw and a motor shaft attached to micromechanical modules, such as a microgear. Figure 2 shows a schematic diagram of the principle of microvalve operation. This novel microvalve can stop the flow of a liquid even in micro space where it is not intercepted completely spatially. The flow rate of a liquid is also controllable by precise submicron step position control of micro needle-head up and down. Surface treatment of the whole microvalve was very important for fluid control [2]. The surface of the whole microvalve was hydrophobic. The shape of the micro needle-head is also very important factor for...
Figure 1. Schematic diagram of top and side view of the micro needle-head type microvalve unit (size of micro stepping motor: Φ: 5mm, height: 8mm, size of unit: 22 x 14 x 21.5mm).

stopping a flow in a microchannel. Figure 3 shows pictures of the micro stepping motor drive unit. Figure 3 (a) shows a picture of a micro stepping motor, a microgear box and a microgear. Its force and pulse is 500gf and 100ppps. Figure 3 (b) shows a picture of a micro ball screw. Its diameter is 1.8mm and pitch is 0.5mm. Figure 3 (c) shows a picture of a micro motor drive unit. Using this motor drive circuit, the velocity of the micro needle-head is controlled at variable speed (0.5μm/s to 200μm/s).

3. Results and discussion

Figure 3 shows microscopic images of the micro needle-head slide valve unit under an inverted microscope. The width of a microchannel is 200 μm. The diameter of a micro needle-head is about 190 μm. The microvalve is open. (left image) The microvalve is close. (right image) Figure 4

Figure 2. Schematic diagram of the principle of the microvalve using the micro stepping motor: Φ: 5mm, height: 8mm, size of unit: 22 x 14 x 21.5mm).
Figure 3. Microscopic view of the micro needle-head slide valve unit under an inverted microscope. The width of a microchannel is 200μm. The diameter of a micro needle-head is about 190μm. The microvalve is open. (left image) The microvalve is close. (right image)

Figure 4. Microscopic view of the micro needle-head slide valve unit closed in a microchannel. An air bubble was stopped at the micro needle-head.

shows a microscopic image of micro needle-head slide valve unit closed in a microchannel. An air bubble was stopped at the micro needle-head. To demonstrate its performance, we also apply this system to packing microbeads [3-5] and analysis for immuno assay in a microchannel using this microvalve, as shown in Figure 5 [3, 4].

4. Conclusions

This paper describes the development of a novel micro needle-head slide microvalve actuated by the micro stepping motor and the smallest micro ball screw in the world for microfluidic devices. We believe that a number of applications for microfluidic experiments will be possible by using this novel and robust microvalve unit.
References

Figure 5. Schematic diagram of microchip based immunoassay system using micro needle-head slide microvalve unit.