An Easy Fabrication Technique for Micro Paraffin Actuator and Application to Microvalve

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Recently, micro reactors and micrfluidic devices attract great interest. In the devices, microvalves are key component for precise control of fluids. In the microvalves, various kinds of actuators are utilized.[1] Among them, thermopneumatic actuators using paraffin as an actuation material are superior in the device that require high pressure and high displacement. Edwin et al.[2] and Klintberg et al.[3] reported the micro paraffin actuators and application to microvalves. In the former, paraffin was deposited by CVD. In the latter, paraffin was injected by using special apparatus. The present study provides an easier fabrication technique for micro paraffin actuators. A property of the normally open microvalve utilizing the actuator is also described.

The paraffin actuator was fabricated as follows: First, a 0.5 mm-thick stainless plate with drilled hole 5 mm in diameter was thermally bonded to polyimide sheet coated with Pt heater (300 Ohm). Next, the hole was filled with melted paraffin followed by polish leading to flat surface. Finally, a 5 μm-thick parylene-C film was coated to yield to the micro paraffin actuator.

Figure 1 shows the displacement of the center of the fabricated micro paraffin actuator as a function of applied voltage. The displacement at the applied voltage of 16 V is as high as 140 μm.

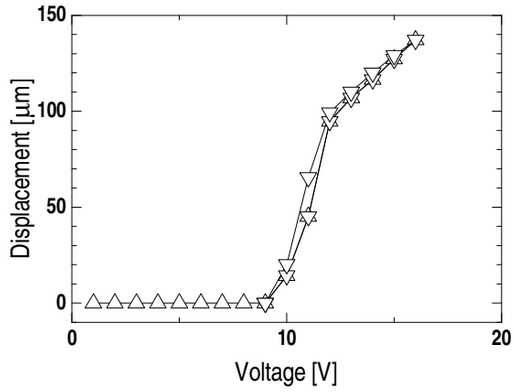

Figure 1. The displacement of the center of the fabricated micro paraffin actuator as a function of applied voltage.

We designed and fabricated a normally open microvalve utilizing the micro paraffin actuator. A schematic of the microvalve is shown in Fig. 2. The size of the actuator is 13 x 20 x 1 mm^3. The actuator with drilled inlet hole and a stainless steel with drilled outlet hole were connected by screws and epoxy as a seal material. The microvalve shut the introduced gas by closing the 25 μm-thick gap with expanded paraffin.

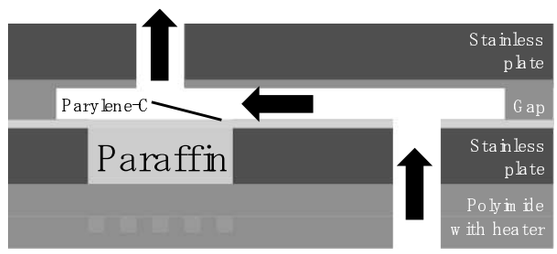

Figure 2. Schematic of the present microvalve.

An open-close property of the fabricated valve as a function of applied voltage is shown in Fig. 3. When the voltage is increased, the valve began to be closed at 10 V. The result agrees with Fig. 1. While, in case the voltage is decreased, the valve began to be open at 8 V. This may be due to stiction between parylene-C film and polyimide sheet.

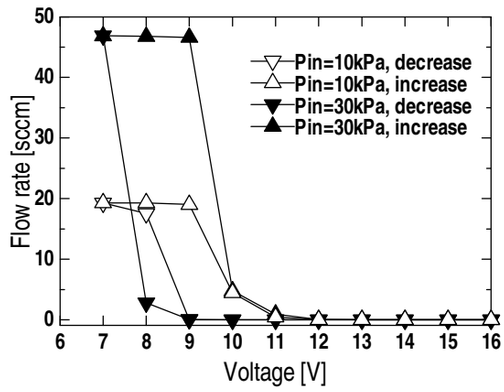

Figure 3. Open-close property of the fabricated valve as a function of applied voltage at the inlet pressure of 10 kPa (open triangle) and 30 kPa (closed triangle)

In Fig. 4 is shown an open-close property of the present microvalve as a function of inlet pressure. The flow rate at the outlet of the microvalve when the valve is open or closed is measured as a function of inlet pressure. The applied voltage to the actuator was set to 16 V. The flow rate when the valve is closed is less than 0.1 sccm in the inlet pressure range of 0-100 kPa. The open/close ratio of the flow rate is achieved to more than 1000.

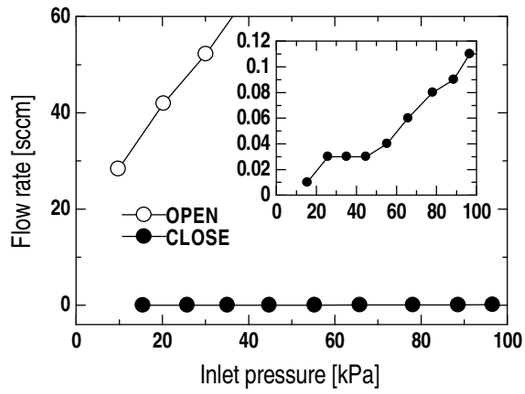

Figure 4. Open-close property of the present microvalve as a function of inlet pressure. The voltage is set to 16 V.

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[3] L. Klintberg et al., Sensors and Actuators A, **105**, 237-246, 2003.