PDMS MICROFLUIDIC DEVICES WITH PTFE PASSIVATED CHANNELS
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Abstract
PDMS microfluidic devices whose whole inner surfaces are covered with PTFE (polytetrafluoroethylene) are described. The major problems of PDMS fluidic devices in practical use, are surface degradation with organic solvents and unexpected absorption of chemical materials. In order to overcome these problems, spin/dip coated perfluoro amorphous polymer is used to form the passivation PTFE layer of 0.2-5μm thick on the PDMS microstructures. A prototype of PTFE passivated pneumatic microvalve was fabricated, and its valve actuation was evaluated.

Keywords: PDMS, PTFE coating, microvalve

1. Introduction
In recent years, PDMS is one of the most commonly used materials for microfluidic devices [1]. PDMS has significant advantages for chemical and biochemical applications, easy fabrication, transparency, low cost, etc. However, PDMS has two significant problems in practical use for chemical and biochemical applications. One is dissolution or swelling by organic solvents [2], and the other is absorption of chemical materials, for instance fluorescence dye and bio-molecules. To overcome these problems, perfluoro amorphous polymer coating on the PDMS microstructures was performed.

2. Concept
Fig.1(a) shows schematic of the PTFE coated PDMS channel. It consists of an upper PDMS part having inlet/outlet and a lower part having a groove. The PDMS surfaces of both parts are covered with PTFE membranes, which act the binding layer as well as the passivation layer. The fabrication steps are shown in Fig.1(b). Perfluoro amorphous polymer (CYTOP, Asahi Glass Company, Japan) is coated by spin coating or dip coating which enables the thickness control from sub-micron to several microns. The CYTOP has high transparency of more than 95% for visible light. In order to realize the uniform polymer coating, O2 plasma pre-treatment to the PDMS surface was indispensable. After pre-curing at 75°C, the top part and the bottom part are bonded at 115°C under pressure of 40kPa, as shown in Fig.1(c). Since CYTOP is thermoplastic polymer, while PDMS is heat-curable, thermal fusion bonding between CYTOP layers can be realized without deformation of PDMS fine structures.
3. Experiment

To evaluate chemical property of the CYTOP passivation layer, XPS (X-ray Photoelectron Spectroscopy) measurement for PDMS with and without CYTOP coating was performed. In the result of wide spectrums range as shown in Fig. 2(a), Si spectrums were not observed at PDMS with CYTOP coating. It indicates the PDMS was covered completely with the CYTOP. Fig. 2(b) shows that the chemical constitution of the coated CYTOP layer corresponds to that of PTFE reference.

To evaluate durability for organic solvent, PDMSs with and without CYTOP coating were dipped into a PDMS solvent, which is TBAF solution (tetraethylammonium fluoride, 1mM in tetrahydrofuran)\(^3\), for 1min. The PDMS pattern without CYTOP coating was dissolved into TBAF, while that with CYTOP coating had no change as shown in Fig. 3.

Absorption of fluorescence dye was tested as shown in Fig. 4. After introducing Rhodamine-B solution (10μM) for 5min, the channel was rinsed by deionized water. In the PDMS channel without CYTOP coating, the fluorescence was still observed after rinse for 30min. On the other hand, fluorescence was not observed in CYTOP coated channel after 10sec rinse.

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**Fig. 2** XPS measurement of PDMS with/without CYTOP coating
The results indicate that absorption of the fluorescence dye is reduced significantly in the CYTOP coated channel. Bio-molecule absorption was also evaluated. Cy5 labeled BSA (bovine serum albumin) solution of 17.6nM and Cy5 labeled λDNA solution of 0.36nM were dropped on the PDMS surface whose half surface was coated with CYTOP. After rinsing with a vortex mixer, fluorescent images were observed and the photograph of the tested PDMS is shown in Fig.5. These both results indicate that CYTOP coating is useful for reducing absorption of bio-molecules such as protein and DNA.

4. Microvalve
A PTFE passivated pneumatic microvalve was fabricated. The basic structure is similar to
the reported PDMS pneumatic valves [2,4].

The PDMS diaphragm of the pneumatic actuator is formed on the glass substrate which has inlet, outlet and pressure access holes. After coating of PTFE, the substrate is bonded to the PTFE coated PDMS structure having a microchannel. Sacrificial layer of positive photoresist is used to prevent bonding between the diaphragm and the bottom part. The sacrificial layer is removed by TMAH (tetramethyl ammonium hydroxide) after bonding. Fig.6 shows open and close status of the valve visualized using Rhodamine-B.

5. Conclusion

In order to improve the durability for organic solvent and to reduce the absorption of chemical/bio-molecules, perfluoro amorphous polymer coated on PDMS micro flow devices and elements were fabricated. Improvement of the durability for TBAF and reduction of the bio-molecules absorption were confirmed. A pneumatic microvalve device with PTFE monolithic inner surface was also fabricated.

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