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# PCR Chip Construction by Taping Method

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**Abstract.** This paper presents experimental results on the adsorption characteristics of the fluorescence material and the DNA amplification performance with respect to various materials constituting microfluidic channels. The experiments showed that the adhesive of the double-sided tape was the reason for the adsorption. Polymerase chain reaction conducted with microfluidic channels made of the selected films and the double-sided tape showed performances comparable to those of DNA amplification by the conventional PCR process.

**Keywords:** Micro-PCR chip, Double-sided tape, PCR, Acrylic adhesive, Microfluidic channel

## 1 Introduction

Labs-on-a-chip (LOCs) are used for various purposes in biotechnology, medical treatment and diagnosis, and basic research [1-4]. The most urgent problems with the use of LOCs are that the fluid of cells and the aqueous solution of biomolecules must be processed stably and inexpensively, and that this process is more favorable as the amount of sample becomes smaller [1, 2, 5, 6, 7]. If tapes are used, which are a thinner and flexible substitute for a microfluidic channel, more efficient and less expensive channel fabrication is possible [2].

Because tapes of various thicknesses are mass-produced, the thermal cycling required for DNA amplification can be effectively conducted by lowering the thermal resistance through selecting a thin tape. Furthermore, the microfluidic channel can be created by simply carving out the tape using cutter plotters. Though the market for LOCs is expanding greatly and so mass-production of the conventional method is established, however, the chip construction by the tapes will be much cheaper because various types of tapes are already mass-produced and their market is very large [2].

The material for the microfluidic channel of a polymerase chain reaction (PCR) chip will have a very large influence on PCR performance. The chip should be thermally stable and the surface over the heater should be very thin. Furthermore, biomolecules should not stick to the material surface and should not adversely affect the biochemical reaction. Material-specific PCR performances have been reported [8], but

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because these experiments were conducted by inserting a piece of material into the PCR tube, they cannot be applied for the case in which fabrication is conducted by using tape. Furthermore, the previous study [8] does not report on the interaction between the material and the fluorescent substance inserted for fluorescence detection after DNA amplification. In this study, we attempted to investigate the changes in PCR performance when tapes of different materials are used. In Section 2, the design and the structure of micro-PCR chips using double-sided tape are discussed, and in Section 3, the PCR performances for different tape materials constituting the PCR chips are shown. The conclusion is presented in Section 4.

## 2 PCB-based micro-PCR chip

The control system for the PCR chip must have user interface functions as well as the basic biochemical functions. The biochemical functions are comprised of processing the protocol and the control of temperature of the chip. The protocol refers to sequential performing of the actions to be conducted at a specific temperature for a certain time period. The whole process can be controlled more easily and efficiently by accessing the embedded system with the user interface on the PC. Accordingly, the local-host structure using PC is chosen for the chip control system architecture. The PCR chip's temperature is controlled in the local system through temperature measurement of the chip thermistor and the periodic control of the heater and fan.

The temperature control speed of the proposed chip was approximately 10°C/s. Therefore the processing period was set to 1/20 s (50 ms) for a margin of error less than 0.5°C and the high precision event timer (HPET) of PC was used to achieve the resolution smaller than 1 ms. The local-host system using the PC has the advantage of reducing the total cost because major functions can be performed in the host [9, 10, 11, 12].

The proposed micro-PCR chip has a four-layer structure. The bottom of the chip was a PCB which had a heater pattern and a thermistor was attached on [13, 14, 15]. The channel was constructed on the PCB substrate using films and tapes.

When the channel was constructed directly on the PCB base, results were not successful because the DNA or fluorescent substances were stuck to the PCB. Therefore, the upper surface of the PCB was covered with a box tape made of polypropylene. A double-sided tape with the thickness of 400-μm was attached on the box tape to act as a channel wall securing the fluid space inside the channel. Finally the chip was covered with polypropylene film, which was a common material in bio laboratories.

## 3 Experiments and Results

Double-sided tape was an important material used to secure space in the micro-PCR chip and it was used to play the role of a channel wall. The tape has to be able to withstand a high temperature of 95°C and the pressure of expansion during the PCR process. Thus, the comparison experiments were conducted by fabricating a microflu-

 

idic channel with #9495MP (3M, USA) and T-#7720(510) (Tapeworld, Korea). Both tapes had an acrylic adhesive, but the carrier part that connects the adhesive surface was made of polyester in #9545MP and polycarbonate (PC) in T-#7720(510). From the experimental results, T-#7720(510) was chosen for a channel wall.

The PCR protocol was composed of a total of 40 cycles of the 15 s denaturation step at 95°C and 1 min renaturation step at 60°C after 10 min preheating step at 95°C. UU DNA of 0.3 ng/μL was mixed with 8 μL of SYBR, 0.4 pM/μL of primer F, and 0.4 pM/μL of primer R. Bovine serum albumin (BSA) of 1 ng/μL was also added to prevent the adsorption.

The polypropylene film, the box tape, one and two layers of T-#7720(510) tape, and one to three layers of #9495MP were tested for fluorescence adsorption by immersing their pieces into the PCR mix with and without BSA. Except the polypropylene film, all other materials showed fluorescent color development and several layers of double-sided tapes showed more vivid fluorescent color. These indicated that the adhesive was a main cause of the adsorption. BSA also seemed to fail to reduce the adsorption of the fluorescence materials onto the adhesive.

As the tested two double-sided tapes showed the similar fluorescence adsorption performance and the T-#7720(510) tape was thicker, it was chosen for the channel construction material. The results of PCR amplification were comparable to them of the conventional PCR with tubes and the conventional thermal cycler despite of the shorter processing time.

## 4 Conclusion

The PCR chip can be more easily constructed using the well-developed PCB production process, and the cost can be reduced by using the inexpensive tapes. Furthermore, the results obtained by the proposed method were almost identical to those of regular PCR, despite that the PCR could be carried out for a shorter processing time than conventional one. As the production process for PCB and tapes are well-developed, the chip cost can be greatly reduced. The mass-production and distribution of the proposed PCR chip system will be possible in near future. However the fluorescence adsorption on the adhesive of double-sided tapes should be seriously considered to integrate the DNA detection process into the chip. The presented experimental results recommend the adhesive part should be exposed to the channel as small as possible.

To commercialize the micro-PCR chip, more massive experiments on fluorescence adsorption should be proceeded. Further DNA amplification experiments, and experimentation using various DNA also will be necessary for fabricating microfluidic channels with double-sided tapes.

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## References

1. D. Patkoa, Z. Martonfalvic, B. Kovacsa, F. Vondervisztа, M. Kellermayerc, R. Horvatha, Sensors and Actuators B 196, 352 (2014)
2. M. Focke, D. Kosse, C. Muller, H. Reinecke, R. Zengerle, and F. Stettenab, Lab on a Chip 10, 1365 (2010)
3. J.J. Ramsden, Biomedical Surfaces, Artech House, Norwood, MA, 2007.
4. M. Malmsten, Biopolymers at Interfaces, Taylor & Francis, New York, 2003.
5. C. Zhang and D. Xing, Nucleic Acids Res. 35, 4223 (2007)
6. C. Zhang, D. Xing, and Y. Li, Biotechnology Advances 25, 483 (2007)
7. D.P. Herzog, IVD technology (2006)
8. R. Kodziusa, K. Xiaoc, J. Wud, X. Yid, X. Gongd, I.G. Fouldsb, and W. Wen, Sensors and Actuators B 161, 349 (2012)
9. C. Plaisant, A. Rose, B. Shneiderman, and A. J. Vanniamparampil, IEEE Software 14, 66(1997)
10. J. D. Kim, Y.U. Lee, and S. Kim, IEICE Trans. Fundamentals E86-A, 859 (2003)
11. J.D. Kim, J. Kim and G. Lee, Efficient control system for PCR chips. Proceedings of SPIE 7929, (2011) Feb. 14, San Francisco, USA.
12. C.Y. Park, J.D. Kim, J.H. Ku, Y.S. Kim, H.J. Song, and J.W. Kim, PCB-based PCR Chip, Sensor Letters 10, 1197 (2012)
13. T.M. Hsieh, C.H. Luo, F.C. Huang, J.H. Wang, L.J. Chien, and G.B Lee, Sensors and Actuators B 130, 848 (2008)
14. K. Shen, X. Chen, M. Guo, and J. Cheng, Sensors and Actuators B 105, 251 (2005)
15. K. Lians, S. O'Rourke, D. Sadler, M. Eliacin, C. Gamboa, R. Terbrueggen and M. Chason, Sensors and Actuators B 138, 21 (2009)

 