Internal Temperature Measurement of Micro PCR Chip with Thermocouple

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Abstract. Polymerase chain reaction (PCR) is a method utilized in most of the experiments handling genetic materials. PCR amplifies the target genetic material that is to be analyzed. Micro PCR chip has a chamber made of double-sided tape and OHP film integrated upon a PCB substrate printed with a heater pattern. The thermistor to measure the chamber temperature is attached to the bottom of the substrate, There exists a gap between the chamber and the thermistor. This experiment measures the temperature difference due to the gap. In the experiment, a thermo-couple was inserted into the chamber directly to measure the actual temperature. The results showed no significant difference between the actual chamber temperature measured by the thermo-couple and the temperature measured by the thermistor.

Keywords: Polymerase chain reaction, micro PCR, temperature measurement

1 Introduction

Polymerase chain reaction (PCR) is a technique to amplify a certain sequence of a complex DNA such as the human genome from a very small amount of DNA solution [1]. Many PCR machines are available on the market. Recently, micro PCR which can amplify the sequence faster using less amounts of reagents conveniently than the conventional PCR machines are taking the center stage [2-5]. The micro PCR chip has a chamber on top of a cover glass, and the cover glass was put on a PCB substrate [3-5]. The thermistor that measures the temperature is attached to the bottom of the PCB substrate, where the heater pattern is printed [3,5]. When constructing a chip as aforementioned, the temperature measured by the thermistor might differ from the actual chamber temperature due to the gap between the thermistor and the chamber. However, it is difficult to measure the internal temperature of the chamber through common means. Since the chamber is made with a thermal tape, cover glass, double-sided tape, and OHP film on top of the printed substrate, the total height of the chamber is only about 400㎛. Thus, it is very hard to insert a common temperature measuring equipment [5].

This paper utilizes a thermo-couple to measure the temperature of chamber by inserting it between the cover glass and chamber of the PCR chip. Because the

thermo-couple is made with a metallic wire, it is easy to change the shape and generally has a small diameter. Therefore it is predicted that if a wire is thin enough, the thermo-couple will be able to be inserted between the double-sided tape and the cover glass that makes up the chamber, or between the chamber and the substrate [6]. The thinnest thermo-couple was selected to prevent the leakage of the solution during the PCR process that occurs when the thermo-couple was inserted inside the PCR chip. The measurement was executed in an embedded environment, identical to the actual micro PCR environment.

2 System Structure

The micro PCR system was constructed as a local-host system consisting of a PCR chip drive with an embedded environment, and a PC providing GUI to control the PCR. The diagram is illustrated in Fig. 1.

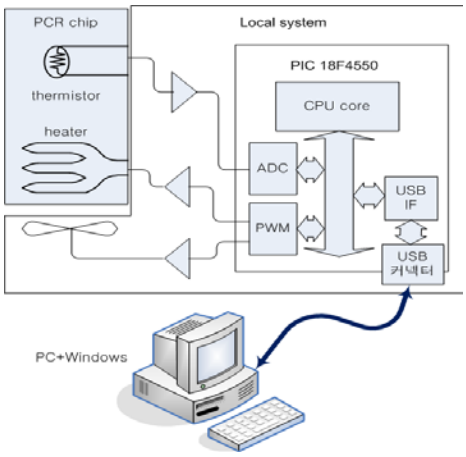

Fig. 1. PCR Chip drive system

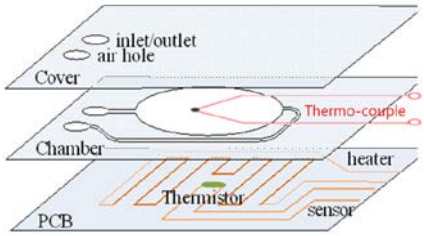

Fig. 2. Disposition of the inserted Thermo-couple

Thermo-couple consists of two different types of metallic wires that are welded at a single junction. It measures the temperature using the thermoelectromotive force produced when a temperature is applied to the junction. The specific thermo-couple utilized in this experiment, which was flexible and thin enough to be inserted in the chamber, was chosen from common K-type thermo-couples. The thermo-couple was inserted both on top of the chamber between the cover OHP film and on the bottom of the chamber between the slide glass. The disposition of the thermo-couple is shown in Fig. 2.

3 Experiments and Results

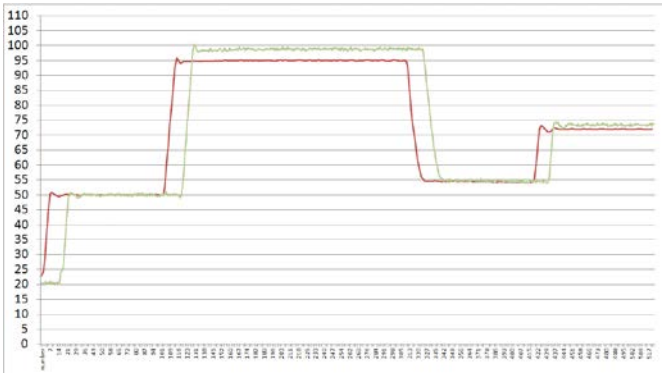

Fig. 3. Measured temperature of micro PCR chamber.

Figure 3 illustrates the results of the temperature measurement of the micro PCR. The red line indicates the temperature measured with the thermistor, and the green line is that of the thermo-couple. The insignificant temperature difference between the thermistor and the thermo-couple seems to be resulted from the contact of the double-sided printed heater pattern to both the water inside the chamber and the thermistor. Since the heat is rapidly conducted to both sides, there is almost no difference in the temperatures measured by the thermistor and the thermo-couple.

In figure 3, a temperature difference of about 4℃ can be observed in the 90℃ section. However, regarding the results from the constant-temperature water bath experiment, which showed 4℃~5℃ temperature difference at 95℃, it can be said that there is no significant difference between the internal chamber temperature and that of the bottom side of the PCR chip.

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