DEVELOPMENT OF MICRO-HEATER ARRAY DEVICE WITH REGIONAL SELECTIVE HEATING FOR BIOCHEMICAL APPLICATIONS

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ABSTRACT
This paper reports the development of the micro-heater array device to expand the versatility of biochemical applications by using micro-heater, and the applicability of the thermo-responsive gel by using this micro-heater array device. To apply to the field of biochemistry, design and materials of micro-heater array device were optimized and fabrication process was established. This micro-heater array device is possible to be heated regionally selectively, controlled to arbitrary temperature and as such, generated temperature gradients. The usefulness of this device was verified using a thermally responsive gel, and generation of temperature generation on a glass substrate was successfully.

KEYWORDS: Micro heater, Heater array, Temperature control, Temperature gradients

INTRODUCTION
Micro-heater possible to be supplied with heat in rapid-response and as such, is one of reliable heater systems. Based on this characteristic that can achieve high response in micro-scale, a number of applied researches have been studied [1]. Micro-heater is also used in applied research using biological cells in recent years, and it is expected to control the expression of cell functional and alteration of cellular morphology. To expand the versatility of biochemical applications by using micro-heater, development of micro-heater array systems is required. Specifically, micro-heaters have a two-dimensionally arrayed structure as a DMD (Digital Mirror Device), are possible to be heated regionally selectively at arbitrary place, and to establish a process flow at low cost and short times.

Although there are many research reports on the fabrication of micro-heater [2], there are few reports on the development of the micro-heater arrayed. Therefore in this research, we aimed to develop a micro-heater array device applicable to the field of biochemistry.

EXPERIMENTAL
Design guidelines include heatable regionally selectively at arbitrary place and applicable to biochemical experiments. Based on these design guidelines, micro-heater array device integrated heater elements digitally on a glass substrate that is easy to prepare at a low cost has been designed. Moreover, to heat regionally selectively, structure of the wiring has been invented.

Heating elements and lead wires are fabricated by chromium (Cr) which is suitable material for micro-fabrication and very stable both electrically and mechanically. And crossing structure that lead lines are not energized was invented. This wiring method is to enable the regional selective heating. Schematic and processing flows are shown in figure 1. Firstly, heating elements and lead wires are patterned by use of deposition and photolithography (a). Secondly, silicon dioxide for insulating the lead wires are also patterned (b). Finally, to connect decoupled lead wires, chromium is also patterned (c). Therefore this micro-heater array device is made of only two materials of silicon dioxide and chromium. In this time, heater elements set the size of 100μm x 100μm at intervals of 200 μm.

Moreover, to verify the usefulness of this device, heating experiment using a temperature responsive gel which is cured at 32 degrees C was conducted.

RESULTS AND DISCUSSION
Microscope photographs of micro-heater array and its enlarged view are shown in Figure 2. Based on results of this microscope photograph and continuity test, the success of the fabrication of the micro-heater array device that can be regionally selectively heating has been confirmed. And as shown in figure
3, the selectively heating by applying a voltage was confirmed. The white discoloration by gel curing is confirmed, and boundary line of the solid and the liquid is 32 degrees C.

Since it possible to be disposed digitally temperature distributions on a glass substrate, if in combination with (P(PAAm) thermoresponsive polymer that can control the hydrophilic-hydrophobic temperature changes, high speed patterning of a hydrophilic-hydrophobic possible. Therefore, realization of a high efficiency separation of proteins, steroids, amino acids, and peptides are expected. If in combination with temperature responsive gels, since regional drug release is possible, elucidation of the functional expression of cells is expected.

![Figure 1: Schematic and processing flow. (a) Cr heating elements and lead wires are patterned by use of deposition and photolithography. (b) SiO₂ for insulating the lead wires are also patterned. (c)Cr is also patterned for connecting lead wires.](image)

![Figure 2: Microscope photographs of micro-heater array. SiO₂ for insulating the lead wires is patterned.](image)

![Figure 3: Results of the heating by applying a voltage. The white discoloration is cured gel.](image)

**CONCLUSION**

Micro-heater array device that was developed in this research has several advantages. Firstly, it is possible to be manufactured at low cost. Secondly, it is possible to heat regionally selectively. Thirdly, since heat is generated by applying a voltage, the generation of a temperature gradient and temperature control is also possible. Fourthly, it is also possible to integration with sensors, actuators and circuit by adopting semiconductor process. Therefore, not only expands the versatility of biochemical applications by using micro-heater, but also deployments of applied research than ever before are expected.

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**REFERENCES**


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