MEMS IN BIOMEDICAL APPLICATIONS

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There has been an increasing interest in developing miniature devices for applications in medicine and biology. Some unit procedures, such as capillary electrophoresis (CE) [1,2], polymerase chain reaction (PCR) [3,4], sample preconcentration [5], and electroporation (EP) [6-8], have been successfully miniaturized and operated on a single-step chip. However, there is still a considerable technical challenge in integrating these procedures into a multiple-step system. The present paper describes achievements of the biomedical applications in MEMS, such as PCR, CE, EP microchips and microfluidic driving system.

MEMS-based PCR chambers great progress has been made in miniaturizing and shortening thermal cycle time. These microfabricated PCR devices have the advantages of small sample volume, rapid thermal cycle and low cost. The micro-PCR chip, shown in Fig. 1, used a T.E. cooler and a closed loop temperature control system to provide the necessary temperature cycles for PCR amplification. SYBR Green I dyes work as fluorescent probe when they bind with DNA double helix, and provide a way for real-time monitoring during the PCR process.

The tee-type preconcentration CE microchip is designed to increase the sample concentration and improve the detection signal in a CE chip. A thin film electrode was located right at the injection tee to provide the electrical contact for one end of the injection channel and accumulate the DNA sample into the tee pouch. This function preconcentrates the DNA sample before separation.

Two kinds of EP microchips are discussed in the present study: the flow-type and an *in-vitro* EP microchips, shown in Fig. 2. The EP microchips can achieve the necessary electric field with a much lower required applied voltage, avoid the potential risk of using high voltage and dissipate heat quicker due to large surface/volume ratio.

A bi-directional driving system for microfluids was designed. The total system operates with an external pneumatic actuator and an on-chip planar structure for airflow reception. The pumping actuation is introduced to the microchannel by blowing one or two airflows through this airflow receiver, which is a simple planar structure without moving parts. The driving module is composed of the suction and exclusion components [9]. The driving module was fabricated on PMMA, and its feasibility was examined experimentally. The droplet of water in the microchannel can move forward, backward and stop under control of this driving module.

Microfabrication offers increased flexibility in design and ease of manufacture compared to the processes employed to manufacture macroscale devices. The development of MEMS techniques enhances the progress of the biomedical research. The above achievements demonstrate that biomedical research and applications could be rapidly growing due to the progress of MEMS.

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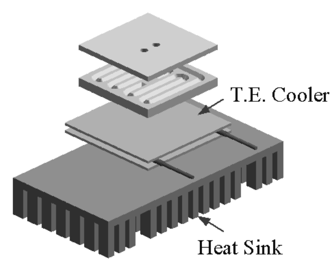
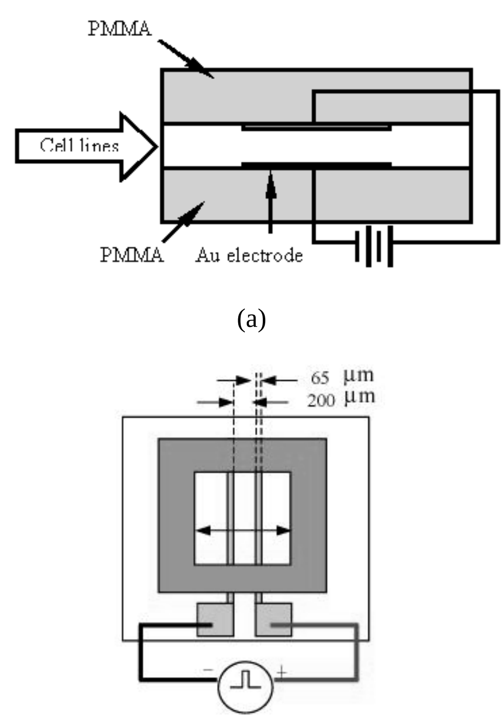


Figure 1 Design of the thermal module with the μ-PCR chip.



(b)

Figure 2 Schematic diagram of the EP microchips: (a) the flow-type EP chip and (b) the *in-vitro* EP chip.