A SELF-CONTAINED MINIATURIZED PCR SYSTEM USING ELECTROMAGNETIC ACTUATORS

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Abstract

In this work, we present the development of a portable polymerase chain reaction (PCR) device. The fully integrated system consists of four major parts: a disposable PDMS chip with microchannels and pumping membranes, a glass chip with micro-heaters and temperature sensors, a linear array of electromagnetic actuators, and a control/sensing circuit. The self-contained system can be fully operated with a 5V DC voltage, and does not require any external air compressor or bulky power supply. The size of the whole system is $67\text{mm} \times 66\text{mm} \times 25\text{mm}$, and is smaller than a PDA cell-phone. The miniaturized PCR system not only has the advantage of smaller size, less consumption of reagent, but also can effectively reduce the PCR process time into one-third of the time required by typical commercial PCR system.

PCR microchip can be classified into two categories, stationary chamber-based PCR amplification and dynamic continuous-flow-based PCR amplification. In chamber-based PCR chip, DNA solution is kept in a chamber which is cycled between different temperatures. In order to reduce the cooling and heating time during the cycles, C. H. Chien *et al* used a tappet to push the silicon chamber through the three temperature regions. In continuous-flow-based PCR chips, micro-channels are designed to guide DNA sample flow through different temperature zones for specific reaction duration. In this work, we develop a self-contained miniaturized PCR system which employs reliable electromagnetic actuators for pushing DNA sample between the reaction chambers made by PDMS polymer. The PDMS chip with micro-channel and micro-chamber structures are fabricated using a SU-8 mold and is bonded to a thin cover glass after an oxygen plasma treatment. Also, micro-heaters and temperature sensors are fabricated on a glass substrate by thin-film deposition and lift-off process. Three chambers in the channel are heated to 94°C, 54°C, and 72°C respectively for the three main procedures, denaturation, annealing, and extension, of amplifying DNA. Successful PCR amplification is performed in the miniaturized

system for MCF-7/adr cell line. First, DNA solution is warmed up to 94° C for 90 seconds. Next, the cycles of different temperatures begins for 25 seconds at 94° C, 25 seconds at 54° C, and 30 seconds at 72° C.

Bibliography

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His research interests include microelectromechanical systems, nanotechnology, high-precision micromachining, flexible sensing arrays, sensor network, parallel processing, and semiconductor devices and vacuum microelectronics modeling. He has been consulted by more than three U.S-based companies and four Taiwan-based organizations. Dr. Yang is a member of IEEE. He is also the recipient of the Outstanding Young Researcher Award of the National Science Council.