

### Non-invasive temperature analysis of micro polymerase chain reaction chip by using liquid crystals and a micro-Raman spectroscopy

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Liquid crystal (LC) thermometry and micro-Raman spectroscopy system were introduced for non-invasive temperature analysis of micro polymerase chain reaction (PCR) chip. The silicon-based micro PCR chip was fabricated by microelectromechanical system (MEMS) technology, and it consisted of a microchannel and a platinum thin film heater and sensor. The temperature of the chip was controlled by in situ temperature control system with the nonlinear feedback proportional-integral control scheme. As the results of the LC thermometry, the average microchannel temperature near annealing temperature (55 °C) was similar to the set temperature measured by the Pt film heater and it was lowered by nearly 1 °C than the control temperature near extension temperature (72 °C). The temperature deviation measured by the LC thermometry were less than  $1.5\text{ °C} \pm 0.5\text{ °C}$  and  $3\text{ °C} \pm 0.3\text{ °C}$  at the annealing and the extension temperature, respectively. The temperature deviation measured by the Raman thermometry varied from  $-1.0\text{ °C}$  to  $+0.1\text{ °C}$  at the annealing temperature.