

## 一种微腔型PCR集成芯片的设计及其热分析

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基金项目：用于脑损伤患者手功能训练的MEMS柔性传感器阵列及其系统集成

摘要：

本文设计了一种新型的硅微聚合酶链式反应（PCR）芯片。该芯片采用掺杂半导体作为加热电阻来提高加热效率，改善反应腔内的温度均匀性。集成在芯片底部的Pt温度传感器与微加热器组成温度控制单元，为PCR反应过程提供所需的三种特定温度。此外，为了便于温度校准，设计了敞开式的反应腔，其容积约1.78 $\mu\text{L}$ 。采用集总参数法计算了芯片在加热和冷却循环过程中的功率和速率，使用ANSYS®软件仿真分析了芯片的热力学特性和热循环过程，优化了加热器的设计方法并获得了合适的加热功率。最后设计了芯片版图及一套可行的工艺流程。本芯片具有体积小、反应速度快、加热效率高和高度集成化等优点。

关键词：聚合酶链式反应芯片；集总参数法；热分析；微机械加工技术

## Design and Thermal Analysis of a Micro-Chamber PCR Integrated Chip

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**Abstract:**

A novel microfabricated Polymerase Chain Reaction (PCR) chip based on silicon is proposed in this paper. A microheater, adopting doped semiconductors as heating resistors, is utilized to increase the heating efficiency and improve the temperature uniformity of the chamber. The temperature control module, which is comprised by the Pt temperature sensor and microheater integrated in the bottom of the chip, can provide three kinds of specific temperature for the PCR reaction process. In addition, an open type reaction chamber with a volume of about 1.78 $\mu\text{L}$  is devised to facilitate temperature calibration. Lumped parameter method is introduced to calculate the power and the rate in the cycle process of heating and cooling. The ANSYS® software simulates the thermodynamic properties and thermal cycling process of the chip. Then an optimal microheater design method and suitable heating power are obtained. Finally, a suit of feasible layout and fabrication process are contrived. The chip mentioned has many advantages, such as small size, rapid reaction rate, high heating efficiency and high integration, etc.

**Keywords:** PCR chip; lumped parameter method; thermal analysis; micromachining technology

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