Electro-Thermal Analysis of a Micro Heater for Lab-on-Chip Applications

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Abstract

The Lab -on -a- chip (LOC) application integrates multiple functionality on a single chip which readily manipulate and delivers the result. Micro Electro Mechanical Systems (MEMS) micro heater is widely used in heating the various Lab -on-a- chip (LOC) application, which has more advantages like long life time, minimum power consumption and compatible to CMOS technology. The in-built micro heater consists of an electrically resistive gold layer of thickness 100 nm deposited on a glass plate. The Micro heater converts the electrical power into heat. The amount of heat to be produced by the conductive layer is decided by the dimension, thermal conductivity and electrical resistivity of material. This paper proposes two different design and electro thermal analysis of serpentine shaped micro heater operating at the temperature range of 150□C-200□C using COMSOL Multiphysics® software. The Micro heater design is solved using Thermal stress and Electric Currents, Shell interface. The design is optimized to provide uniform temperature with minimum input power.

Introduction: The in-built Micro Heaters are essential in various Micro Devices [1] such as Micromixers [2], Micro reactor [3], Polymerase Chain Reaction (PCR) [4], Temperature Gradient Focusing for Electrophoresis (TGF) [5], digital microfluidics [6-7]. The in-built micro heater regulates the temperature in managing the physical, chemical and biological properties with minimal power. In this work, we propose the design and simulation of Micro-heater which is to be embedded along with a Micro-reactor. The Figure 1 shows the cross sectional view of Micro-reactor with embedded Micro-heater. The micro heater consists of an electrically thin resistive Gold layer which is deposited on a glass substrate, and it is sandwiched between PDMS layers. The design was optimized to produce the uniform temperature. The Micro heater with uniform resistance is designed with device dimension of 3cm x 3cm in order to achieve the heat of 150□C-200□C with the operating voltage range of 3-5V and power consumption less than 2 watts. The resistance of the heating element can be calculated using the following relation: $R=\rho L/A$ in Ω where, ρ is the resistivity of the of the heating element in Ωm, L is length in cm, A is cross sectional area in cm2

The Micro heater design was solved using Thermal stress and Electric Currents, Shell interface of COMSOL Multiphysics® software. The temperature profile of micro heater was studied for two different design of 3x12 array and 6x6 array and it is shown in Figure 2 and 3.

The Figure 4(a) shows the Applied voltage versus Temperature graph and Figure 4(b)

shows the power consumption versus Temperature graph of 3x12 and 6x6 micro heater array. From the graph we observe 3x12 and 6x6 micro heater produces target temperature of 150°C-200°C at the applied voltage range of 2.2V to 2.6V and 4.2V to 5 V respectively, with the power consumption of less than 0.5W.

Conclusion: The integration of micro heater with micro reactor has been found to have a good control over the temperature with lesser power consumption.

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