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

S. Kalaiselvi[1], Dr. L. Sujatha[1] , Dr. R. Sundar[1]
1. Rjalakshmi Engineering College, Chennai, Tamil Nadu

Introduction: Micro Electro Mechanical Systems (MEMS) micro heater is widely used in heating the various Lab -on-a- chip (LOC) applications, which integrates multiple functionality in a single chip which readily manipulate and delivers the result. The in-built micro heater embedded along micro reactor consists of an electrically resistive gold layer of thickness 100 nm deposited on a glass plate. The Micro heater with uniform resistance is designed with device dimension of 3cm x 3cm in order to achieve the heat of 150ºC-200ºC with the operating voltage range of 3-5V and power consumption less than 2 watts.

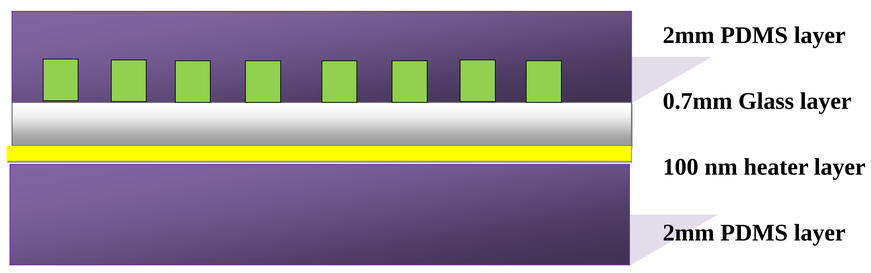

Figure 1 Micro-reactor with embedded Micro-heater

Computational Methods: 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 Micro heater design was solved using Thermal stress and Electric Current Shell solver.The resistance of the heating element can be calculated using the following relation:

$$R = \frac{\rho L}{A} \quad \text{in } \Omega$$

where, ρ is the resistivity of the of the heating element in Ωm, L is length in cm

A is cross sectional area in cm^2

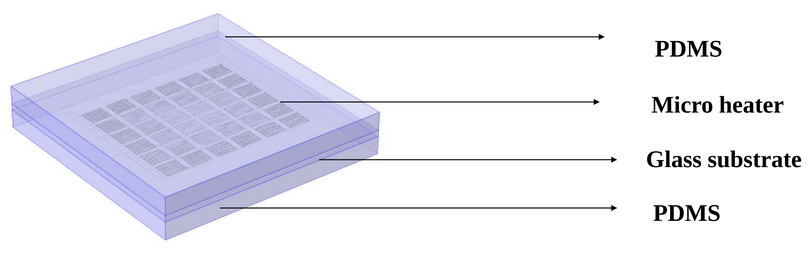

Figure 2 Schematic diagram of embedded Micro-heater

Results: The 3x12 and 6x6 micro heater with equivalent resistance of 15Ω and 60Ω at applied voltage of 2.6V and 5V produces the maximum temperature of 199.6ºC and 196.2ºC with power consumption of 0.456W and 0.422W respectively.

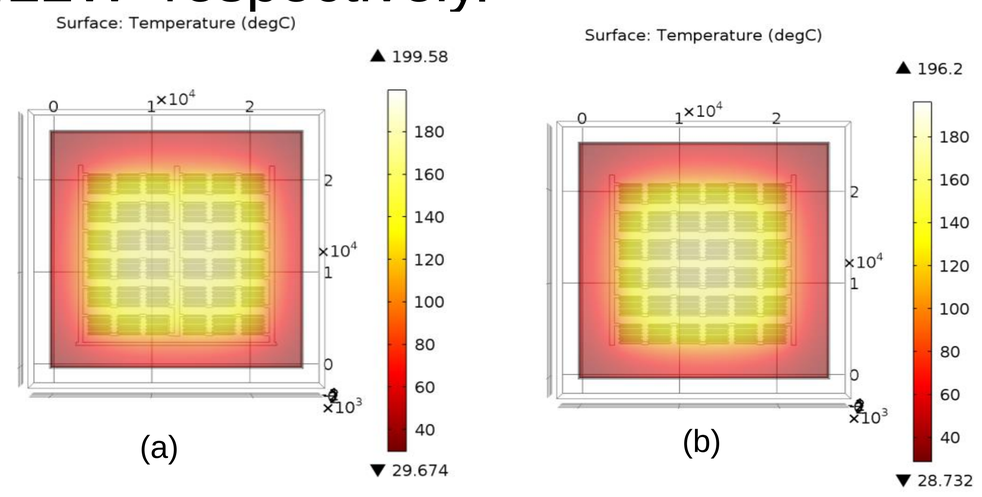

Figure 3. Temperature profile of Micro Heater (a) 3x12 at applied voltage of 2.6V(b) 6x6 at applied voltage of 5V

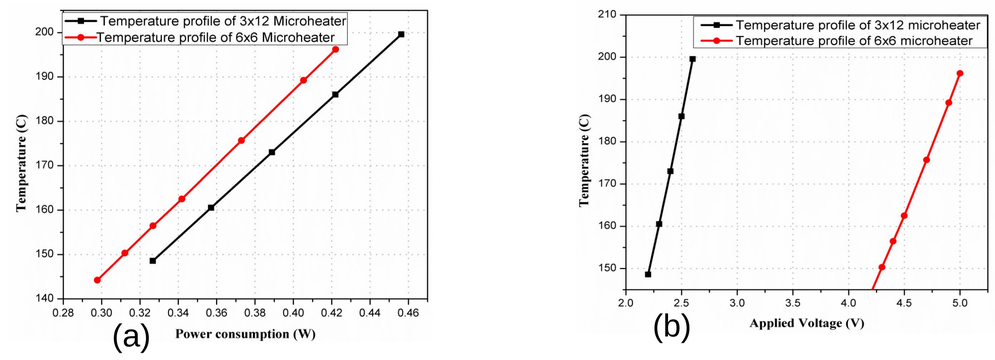

Figure 4. Temperature characteristics (a)Temperature versus power consumption(b)Temperature versus applied voltage

Design 1 (3x 12)array					Design 2 (6x6) array				
Voltage V	Tmax in the heater ^{0}C	Tmax in the substrate ^{0}C	Resistance Ω	Calculated Electrical Power W	Voltage V	Tmax in the heater ^{0}C	Tmax in the substrate ^{0}C	Resistance Ω	Calculated Electrical Power W
2.2	148.58	128.76	14.81	326.72E-3	**4.3**	150.32	131.67	59.231	312.17E-3
2.3	160.53	138.77	14.81	357.09E-3	**4.5**	162.51	142.28	59.231	341.88E-3
2.4	173.02	149.61	14.81	388.82E-3	**4.7**	175.69	152.8	59.231	372.94E-3
2.5	186.03	161	14.81	421.9E-3	**4.9**	189.23	164.48	59.231	405.36E-3
2.6	199.58	171.75	14.81	456.32E-3	**5**	196.2	170.4	59.231	422.07E-3

Table 1. Electro Thermal Analysis of 3x12 & 6x6 Micro heater

Conclusions This paper discusses two different electro thermal design analysis of in-built micro heater for Lab-on -a-Chip applications . The 3x12 and 6x6 micro heater can be suited to 3V and 5V operating applications respectively. The integration of micro heater with micro reactor has been found to have a good control over the temperature with lesser power consumption.

References:

1. Bertrand Selva et al., Integration of a uniform and rapid heating source into microfluidic systems ,Microfluid Nanofluid ,vol 8,pp755–765,(2010)
2. Woo-Jin Hwang et al., Development of Micro-Heaters with Optimized Temperature Compensation Design for Gas Sensors, Sensors, *vol 11*,pp 2580-2591(2011)

Excerpt from the Proceedings of the 2016 COMSOL Conference in Bangalore