SIMULATIONS OF POLYMER BASED MICROHEATER OPERATED AT LOW VOLTAGE

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Outline

- Introduction
- Microheater Modeling
- Simulation and discussion using COMSOL Multiphysics 4.1
- Conclusion

Introduction

- **M**icroheater is device which has many applications in the field of **M**icro **E**lectro **M**echanical Systems(MEMS) such as gas sensor ,PCR device, micro valve, flow rate sensor, etc.

- In present work we demonstrate the simulation results of microheater for three different geometries and estimation of **area over which uniform temperature** is obtained.

- The designed heater will be useful for the applications such as PCR device and gas sensor.

- All three designs were simulated at a constant voltage to get temperature range from 200 to 250ºC .

Microheater Material- Polyimide

Polyimide is used as a heater material.

Advantages of using polymer:

- Compatible with polymer microfabrication process
- Easily available
- Clean room free fabrication procedures with less instrument usage
- Cost effectiveness

Cont.

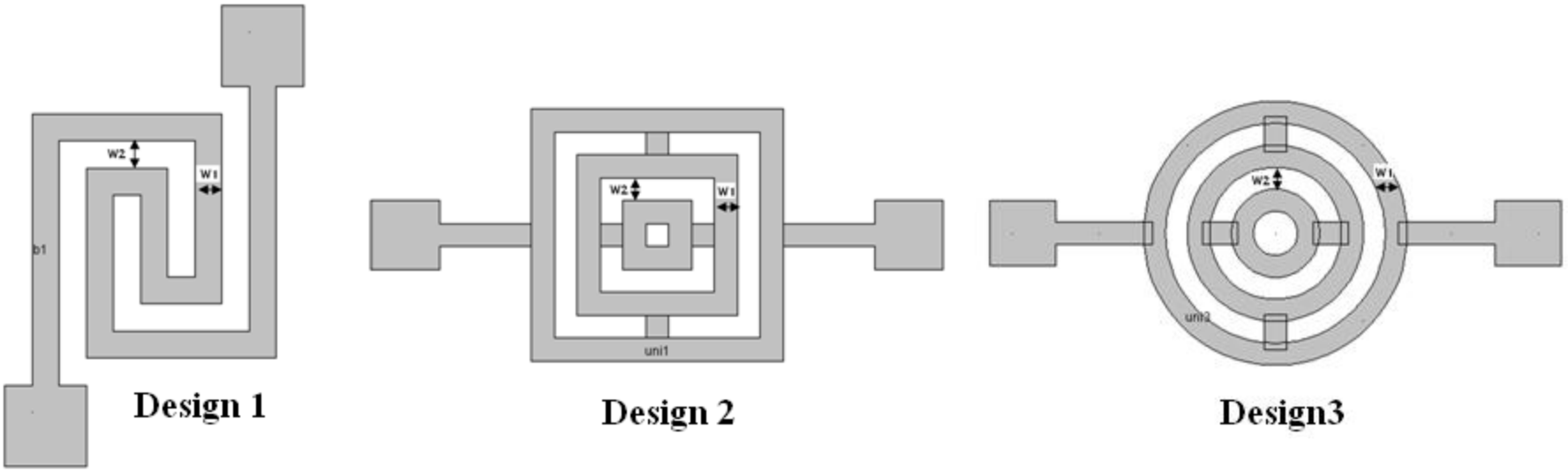
Polyimide properties used for simulations

Parameter	Value
Electrical Conductivity	10(s/m)
Coefficient of Thermal Expansion	$45*10^{-6}$(1/K)
Heat Capacity @ Constant Temperature	1090[J/(kg*K)]
Density	1420(kg/m3)
Thermal conductivity	0.12(W/mk)
Young's Modulus	$2.5*10^{9}$(Pa)
Poisons Ratio	0.32
Relative permittivity	3.1

Microheater Modeling

- Microheater is basically resistive beam which can attain the desired temperature due to joule heating when required power is consumed by it.

Microheater Geometries



W1 = Track width
W2 = Gap width (Gap between two consecutive tracks)

- Simulations are done by varying track width (W1) and gap width (W2)

Simulation using COMSOL Multiphysics

- **Joule heating** module form **COMSOL 4.1** is used to get Elelctro-thermal profile of microheater.
- For all geometries length is taken in **micrometer(μm)**.
- Mesh size is chosen from the **predefined sizes** available in COMSOL.
- **Stationary Solver** is used to get steady state temperature distribution of microheater.
- All three designs were simulated at a constant voltage of **5.2V** to get temperature range from **200 to 250ºC** .

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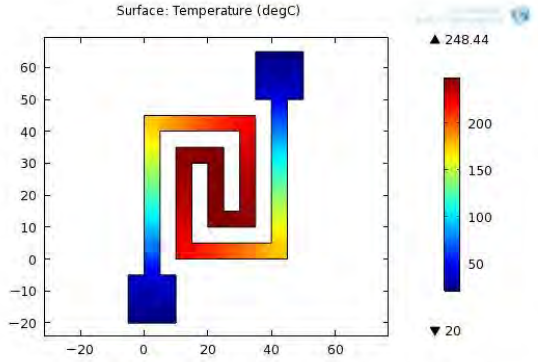
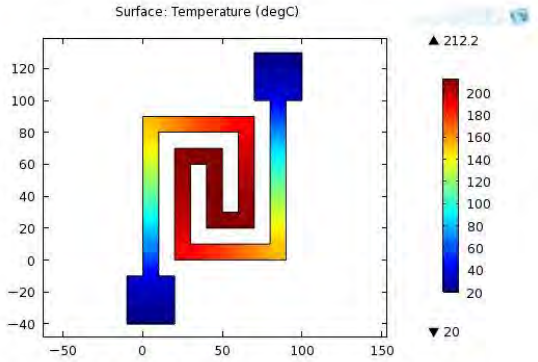
- In microheater simulation, the temperature and potential gradient in Z direction (perpendicular to heater plane) are small in comparison to the gradient in X-Y plane. Therefore the problem simulation reduces to two dimensions.

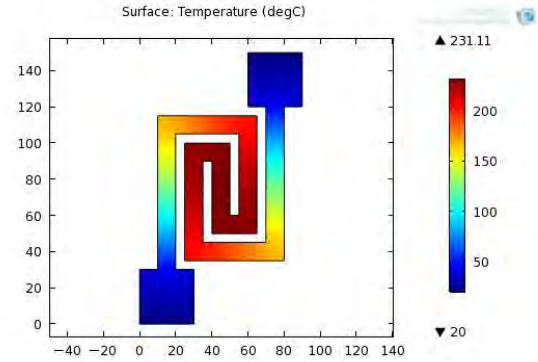
Microheater: Design 1



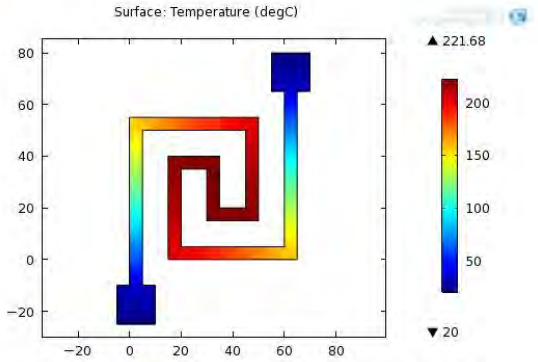
(A) 5µm Track Width and 5µm Gap Width



(B) 10µm Track Width and 10µm Gap Width



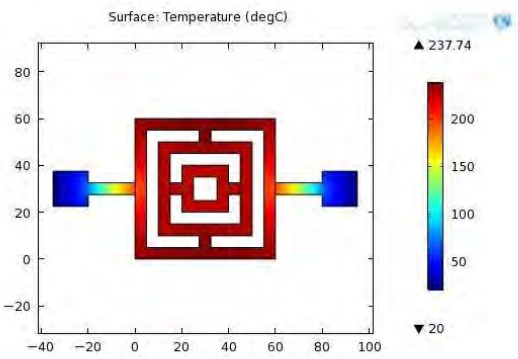
(C) 10µm Track Width and 5µm Gap Width



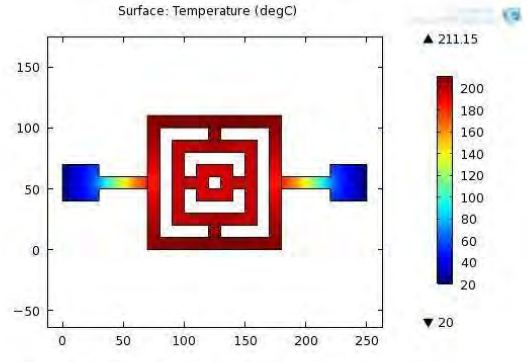
(D) 5µm Track Width and 10µm Gap Width

Design	W1 (µm)	W2 (µm)	Area of uniform temperature(µm²)	Temperature (°C)
A	5	5	25*10	246
B	10	10	50*10	210
C	10	5	45*10	228
D	5	10	25*20	220

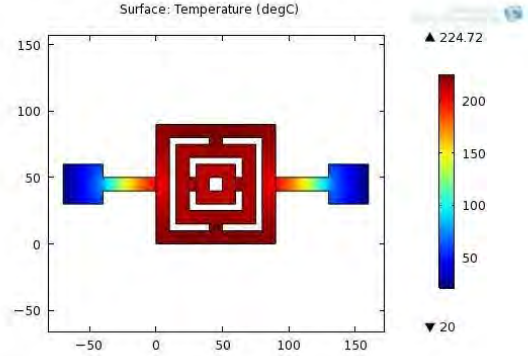
Microheater: Design 2



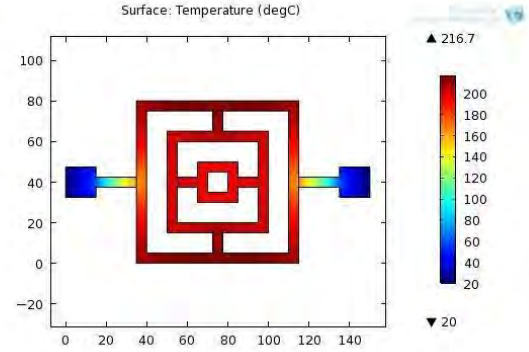
(A) 5µm Track Width and 5µm Gap Width



(B) 10µm Track Width and 10µm Gap Width



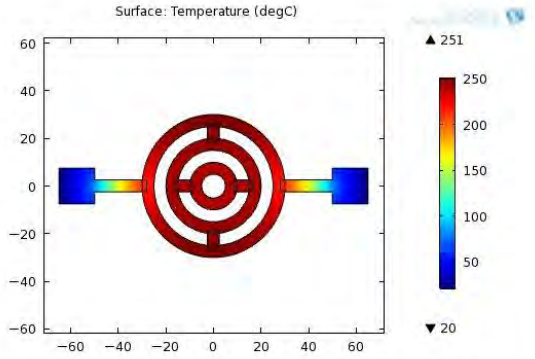
(C) 10µm Track Width and 5µm Gap Width



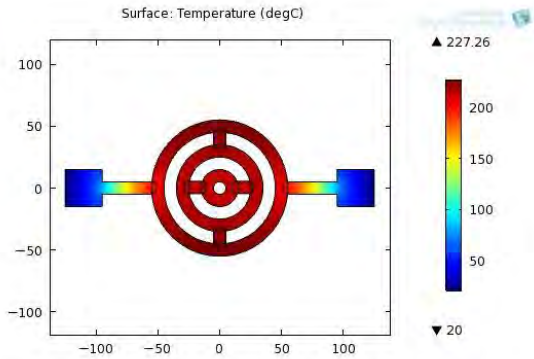
(D) 5µm Track Width and 10µm Gap Width

Design	W1 (µm)	W2 (µm)	Area of uniform temperature(µm²)	Temperature (°C)
A	5	5	40*40	225
B	10	10	70*70	195
C	10	5	60*60	214
D	5	10	50*50	196

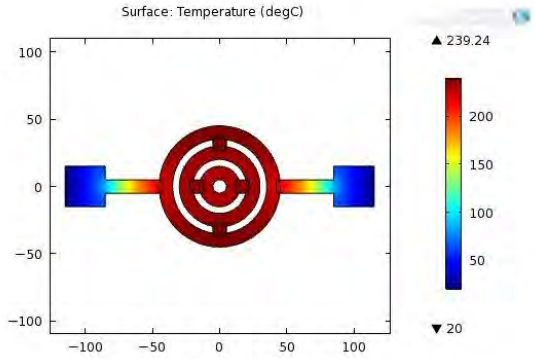
Microheater: Design 3



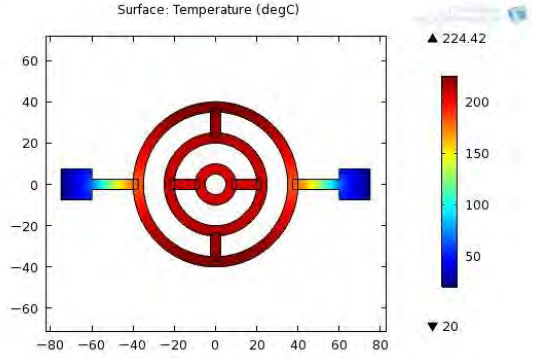
(A) 5µm Track Width and 5µm Gap Width



(B) 10µm Track Width and 10µm Gap Width



(C) 10µm Track Width and 5µm Gap Width



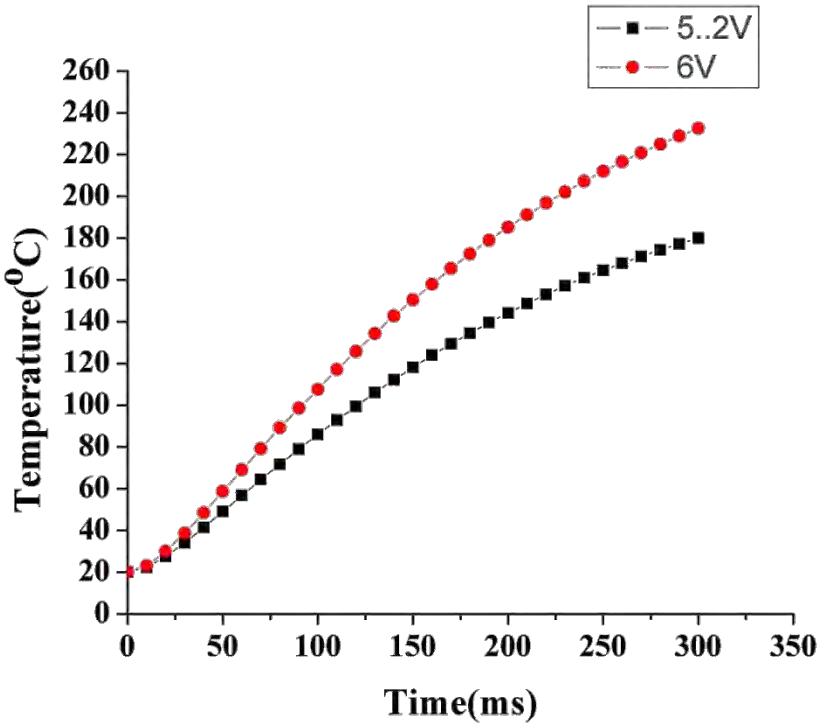
(D) 5µm Track Width and 10µm Gap Width

Design	W1 (µm)	W2 (µm)	Area of uniform temperature(µm²)	Temperature (°C)
A	5	5	40*40	242
B	10	10	70*70	215
C	10	5	60*60	231
D	5	10	50*50	209

Comparison of Simulation Results

Design	Area Covered by the design (μm)	Area of uniform temperature(μm^2)	Temperature(°C)
Design1(A)	45*45	25*10	246
Design1(B)	90*90	50*10	210
Design1(C)	80*80	45*10	228
Design1(D)	65*55	25*20	220
Design2(A)	60*60	40*40	225
Design2(B)	110*110	70*70	195
Design2(C)	90*90	60*60	214
Design2(D)	80*80	50*50	196
Design3(A)	60*60	40*40	242
Design3(B)	110*110	70*70	215
Design3(C)	90*90	60*60	231
Design3(D)	80*80	50*50	209

Time Dependent Study



Response Time from 0 to 300 ms for Design 3	
Voltage Applied (V)	**Temperature (ºC)**
5.2	180
6	232

Conclusion

- With a **heat spreading geometry** of **square design** and **circular design** , area of uniform temperature can be increased

- With **circular geometry edge losses** get reduced.

- From the **time dependent study** it is observed that the **heating rate** can be varied with a change in applied voltage.

Thank you……!