Design and Analysis of Micro-Heaters using COMSOL Multiphysics For MEMS Based Gas Sensor

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Objective

We have looked for geometric optimization of the heater structure to achieve high temperature uniformity by performing analysis using COMSOL Multiphysics 4.2, a Finite Element Analysis (FEA) Package.

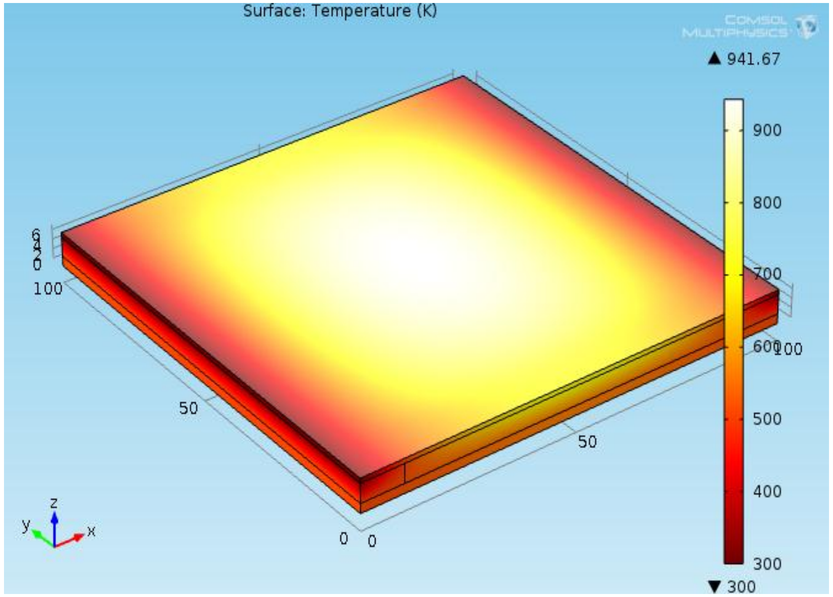
Sensitivity of the Sensor

Sensitivity can be improved by **optimizing the heater geometry** to obtain the following:

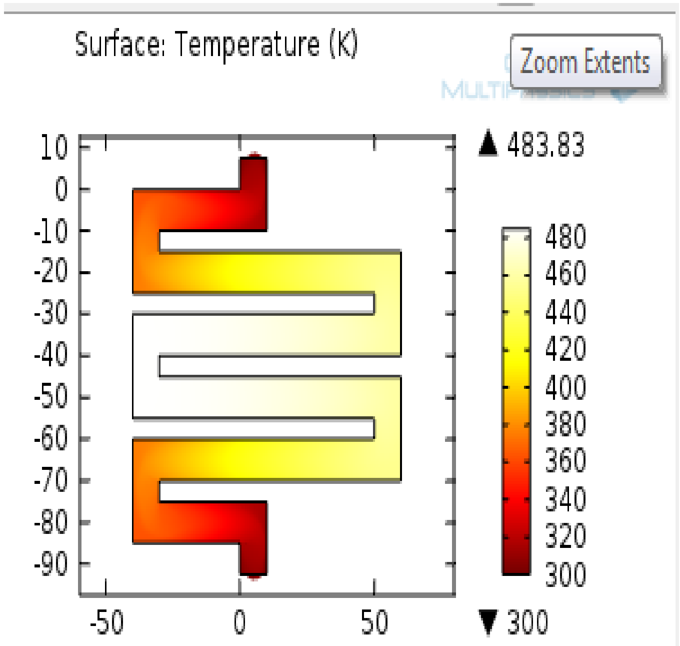
- Maximum Temperature
- Low power Consumption
- More Uniformity of Temperature on the membrane

Simulated Results for Existing Micro Heater Structures

Square Hot Plate



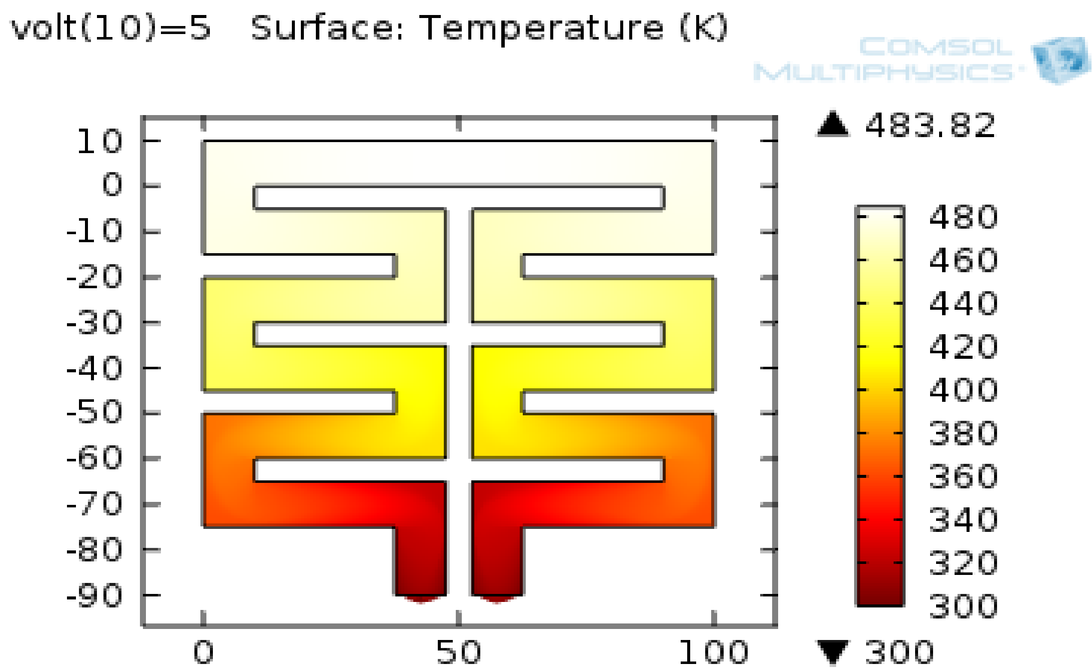
Single Meander



Square hot plate: Max. temperature = 483.83 deg Kelvin
Single Meander: Average temperature = 388.356 deg Kelvin
Percentage of Area Greater than 80% max temperature = 73.14%

Existing Structures – contd…

Double Meander

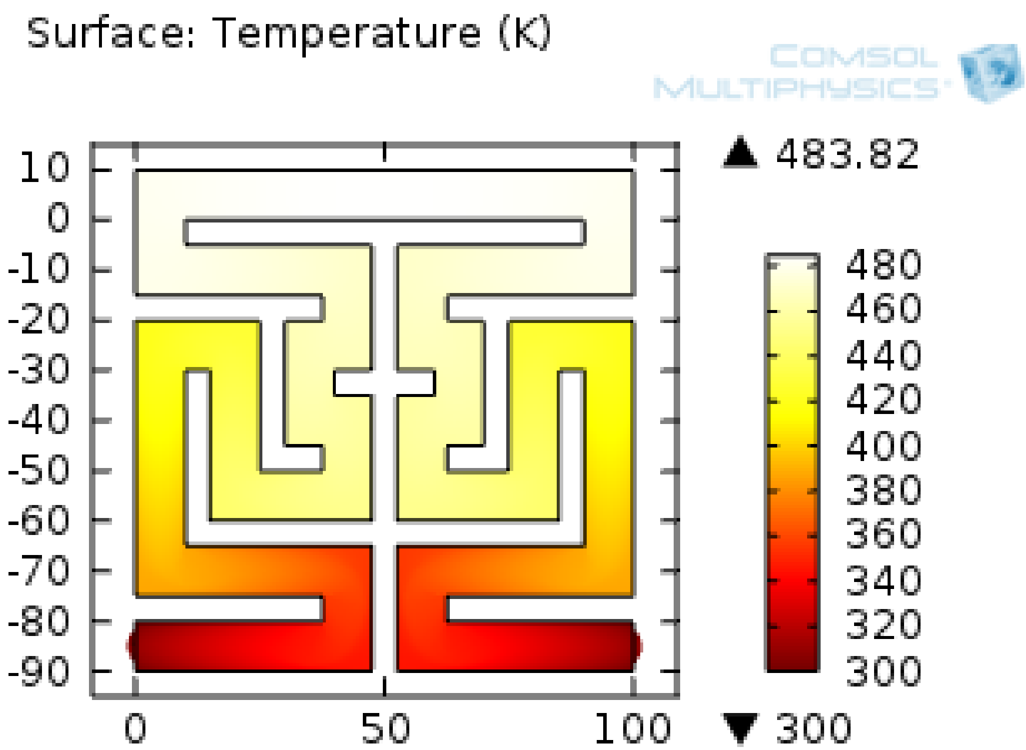


Max. temperature = 483.83 deg Kelvin

Double Meander: Average temperature = 406.906deg Kelvin

Percentage of Area Greater than 80% max temperature = 68.14%

Fan Type



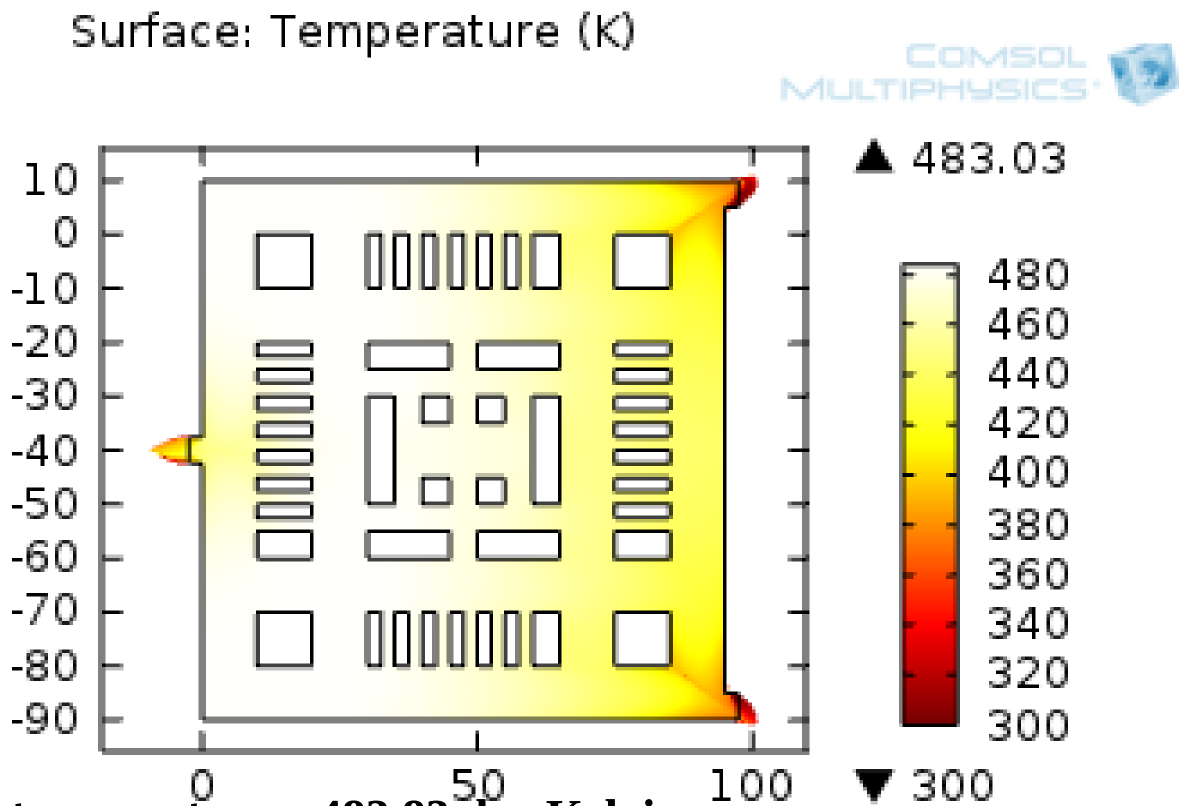
Max. temperature = 483.83 deg Kelvin

Double Meander: Average temperature = 435.725deg Kelvin

Percentage of Area Greater than 80% max temperature = 71.91%

New Heater structures

Type 1: Grill Type

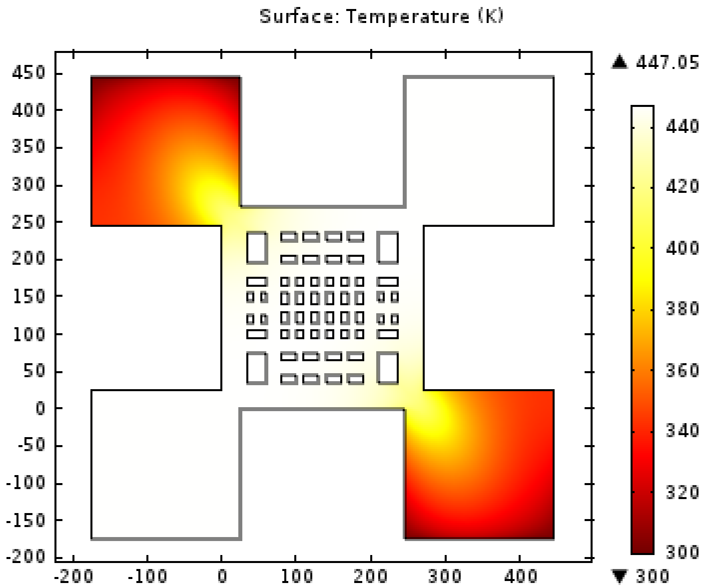


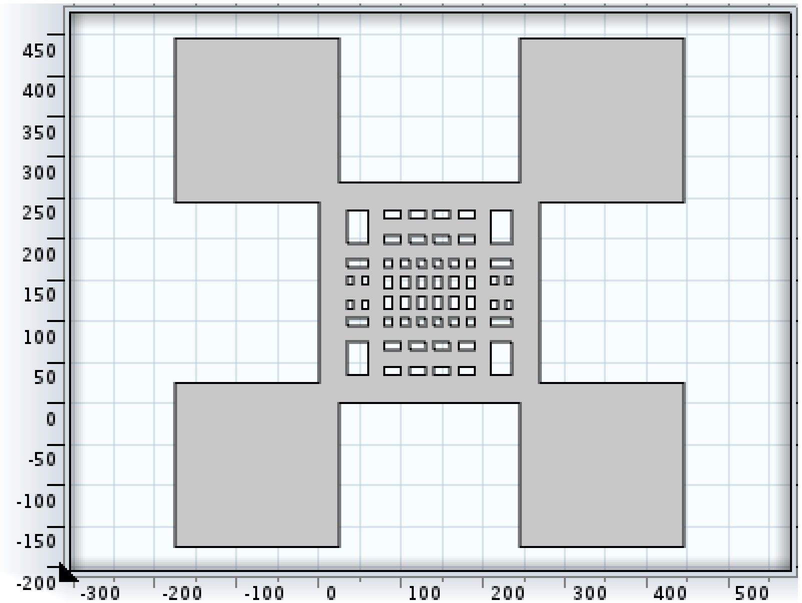
Max. temperature = 483.83 deg Kelvin

Double Meander: Average temperature = 456.442deg Kelvin

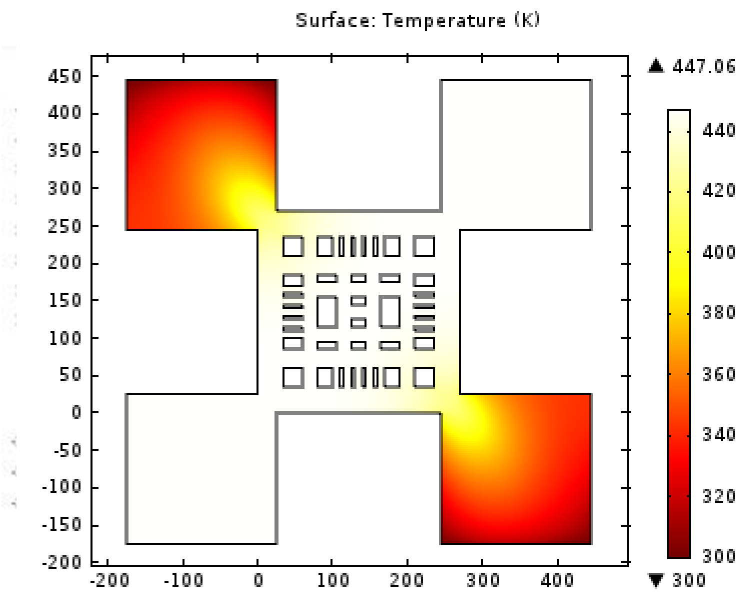
Percentage of Area Greater than 80% max temperature = 99.51%

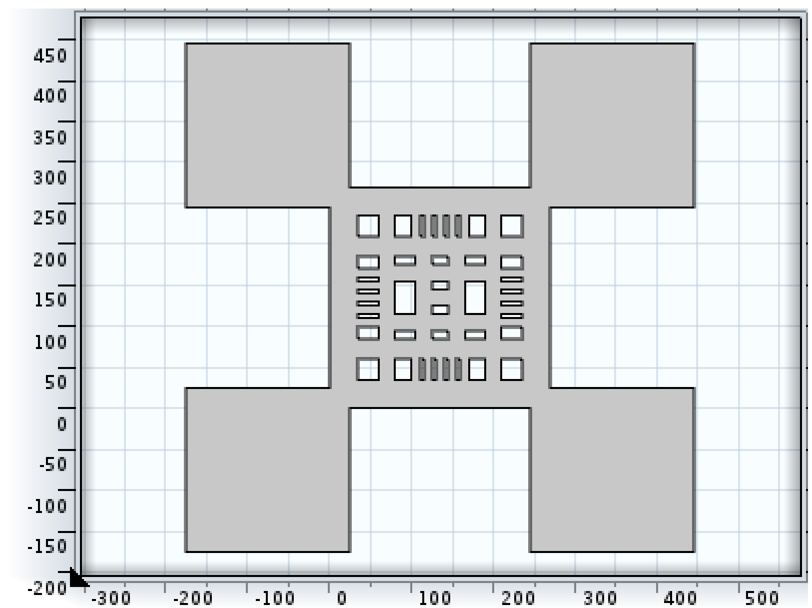
Grill Microheater Type 1



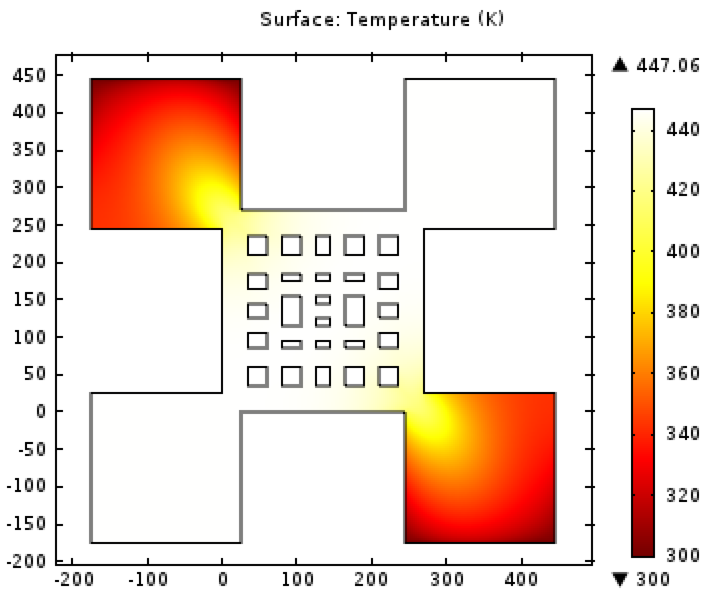


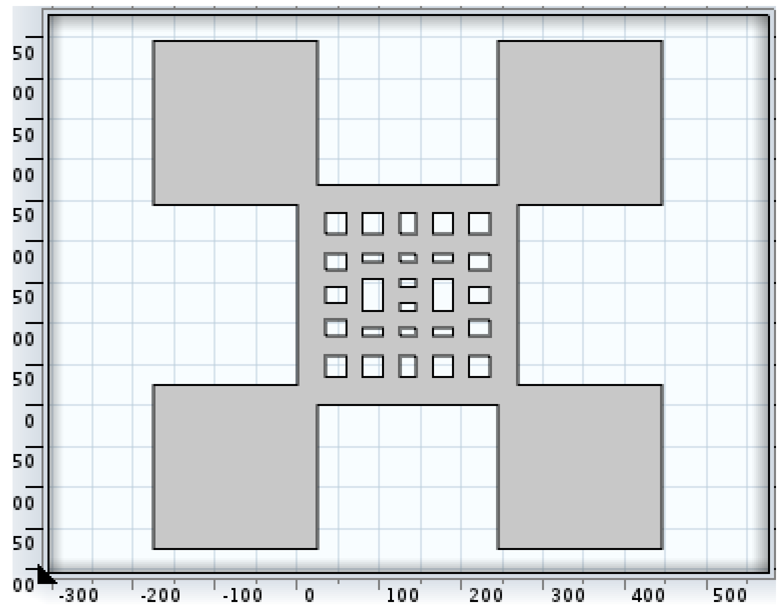
Grill Microheater Type 2



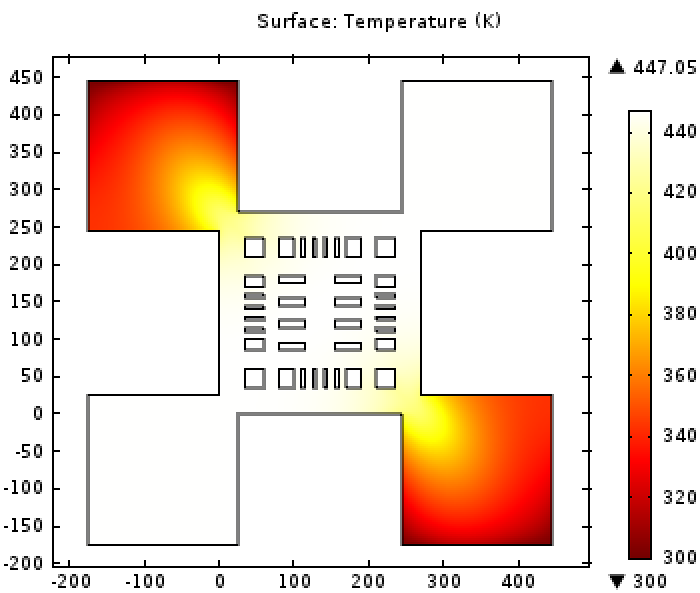


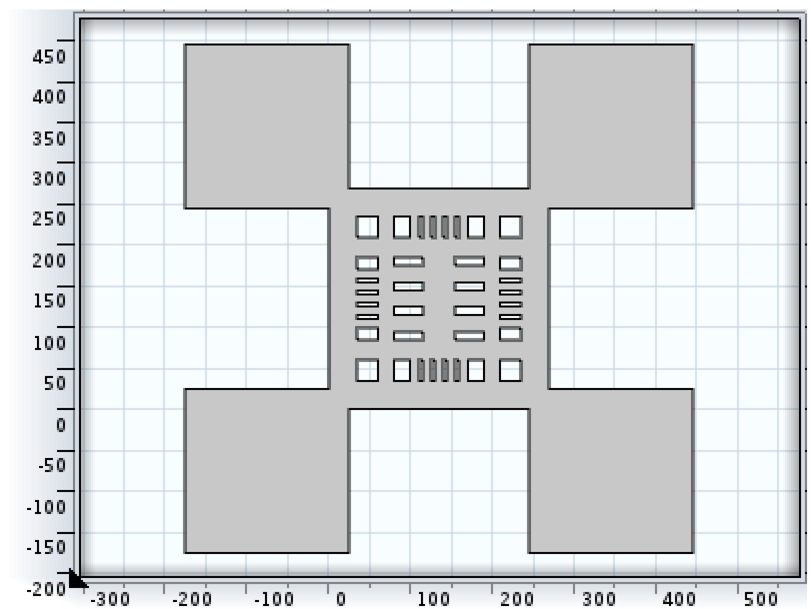
Grill Microheater Type 3





Grill Micro heater Type 4





Results and Discussion

As the voltage is varied from 0.5 to 5 V in increments of 0.5 V the temperature increases exponentially. The same maximum temperature was obtained for all the structures; however there was a notable difference in temperature uniformity

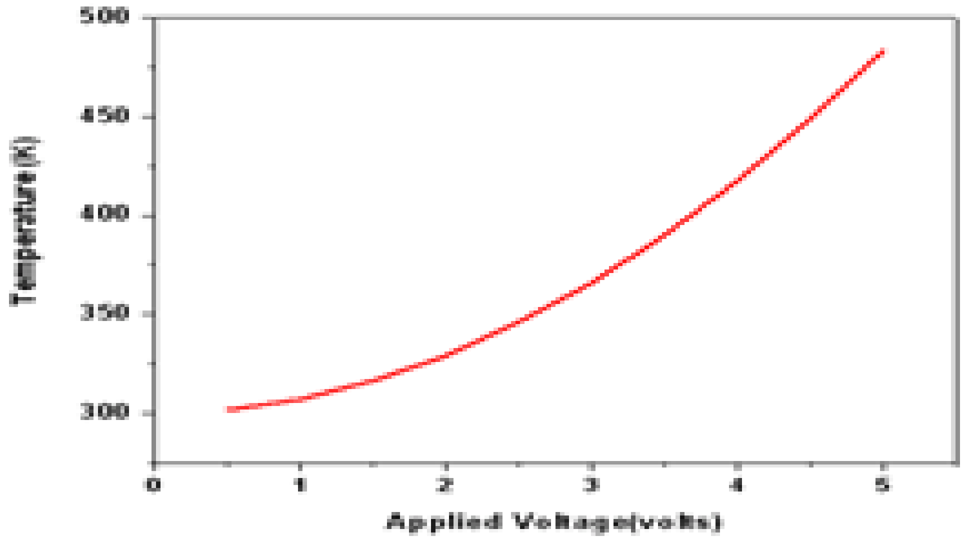


Figure 10: Maximum Temperature Vs Applied Voltage curve for Micro Heater of area 100× 100 μm

Power Calculation

- The heating Power (P) of a microheater can be calculated applying a voltage (V) across the two ends of a resistor (R)

$$P = V^2 / R \qquad (1)$$

- A resistance of thin microheater can be found by using

$$R = \rho L / wt \qquad (2)$$

- Where ρ is the resistivity of material; L is the Length; w is the width; t is the thickness.

References Resources

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THANK YOU