A

Presentation on

3-D Design, Electro-Thermal Simulation and Geometrical Optimization of spiral Platinum Micro-heaters for Low Power Gas sensing applications using COMSOL 4.1

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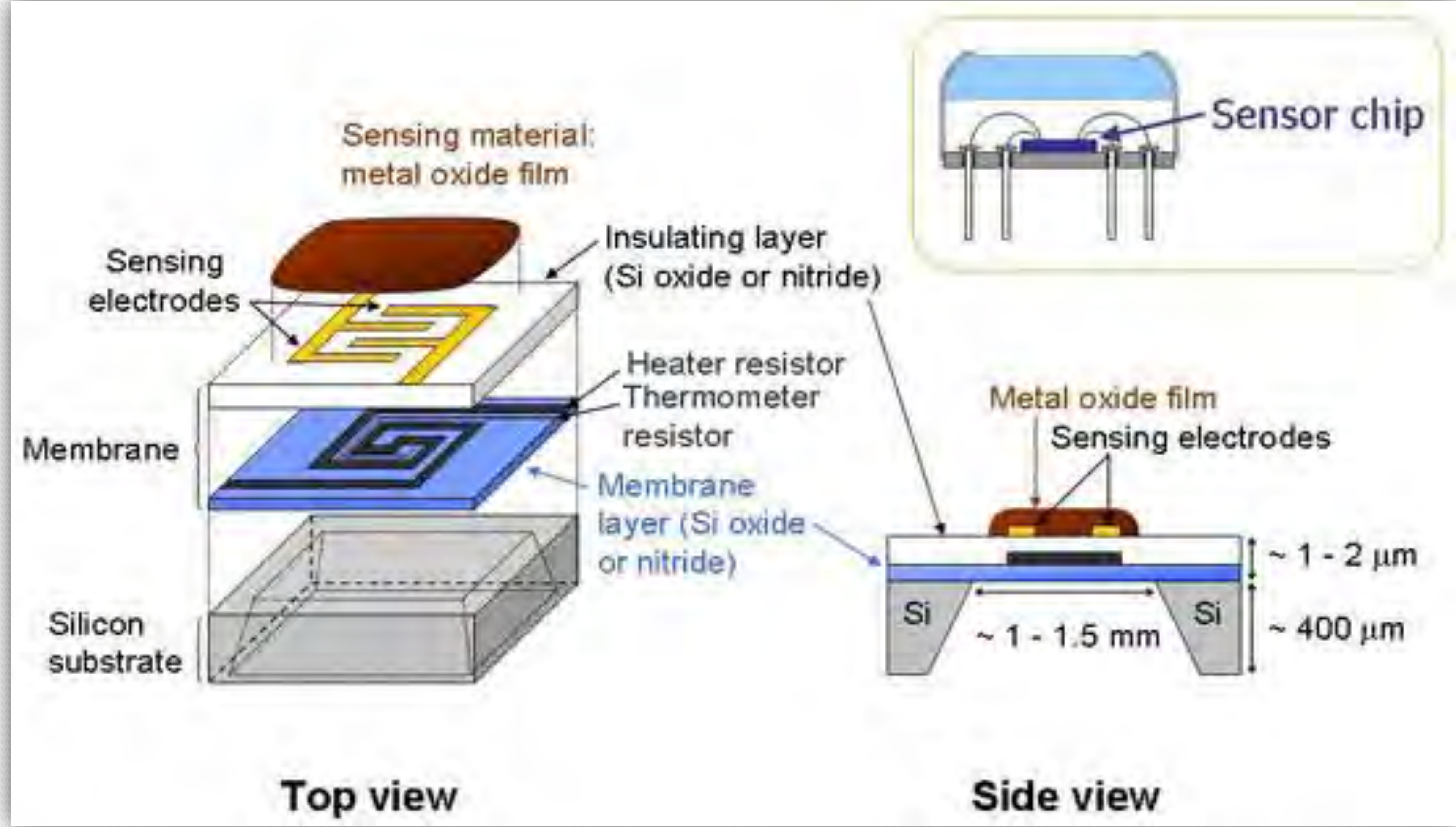
A Integrated MOX gas sensor



Why Gas sensor's

- Gas sensors are the devices which determine the information about the gas present and its concentration in an ambient gas atmosphere.
- Miniaturized gas sensors with a low power consumption for the detection of various gases such as CO, CH4 and H2 is very essential for a wide range of applications.
- The Micro-heater is the main component in resistive gas sensors to make the sensing layer more sensitive and selective. Unfortunately which is also a most power consuming part in gas sensors.
- Hence perfect design and fabrication of Micro-heater is an important aspect.

What are Micro-heaters

- Micro heaters in gas sensors are basically resistive beams which can attain a temperature of 300C - 500C due to joule heating, when sufficient voltage is applied across the ends.

- The design of micro-heaters is optimized for…
  low power consumption
  low thermal expansion
  Better Temperature uniformity across the device
  Enhanced thermal isolation from the surroundings

Materials For Micro-heaters

Materials

Poly-silicon
Low Temperature
Highest Thermal Expansion
Established Fabrication
cheap

Platinum
High Temperature
Average thermal Expansion
Hard to Fabricate
Costliest

Tungsten
Very High Temperature
Low Thermal Expansion
Ease of Fabrication
Cheap

Gold
Highest Temperature
Low thermal Expansion
Hard to Process
Costly

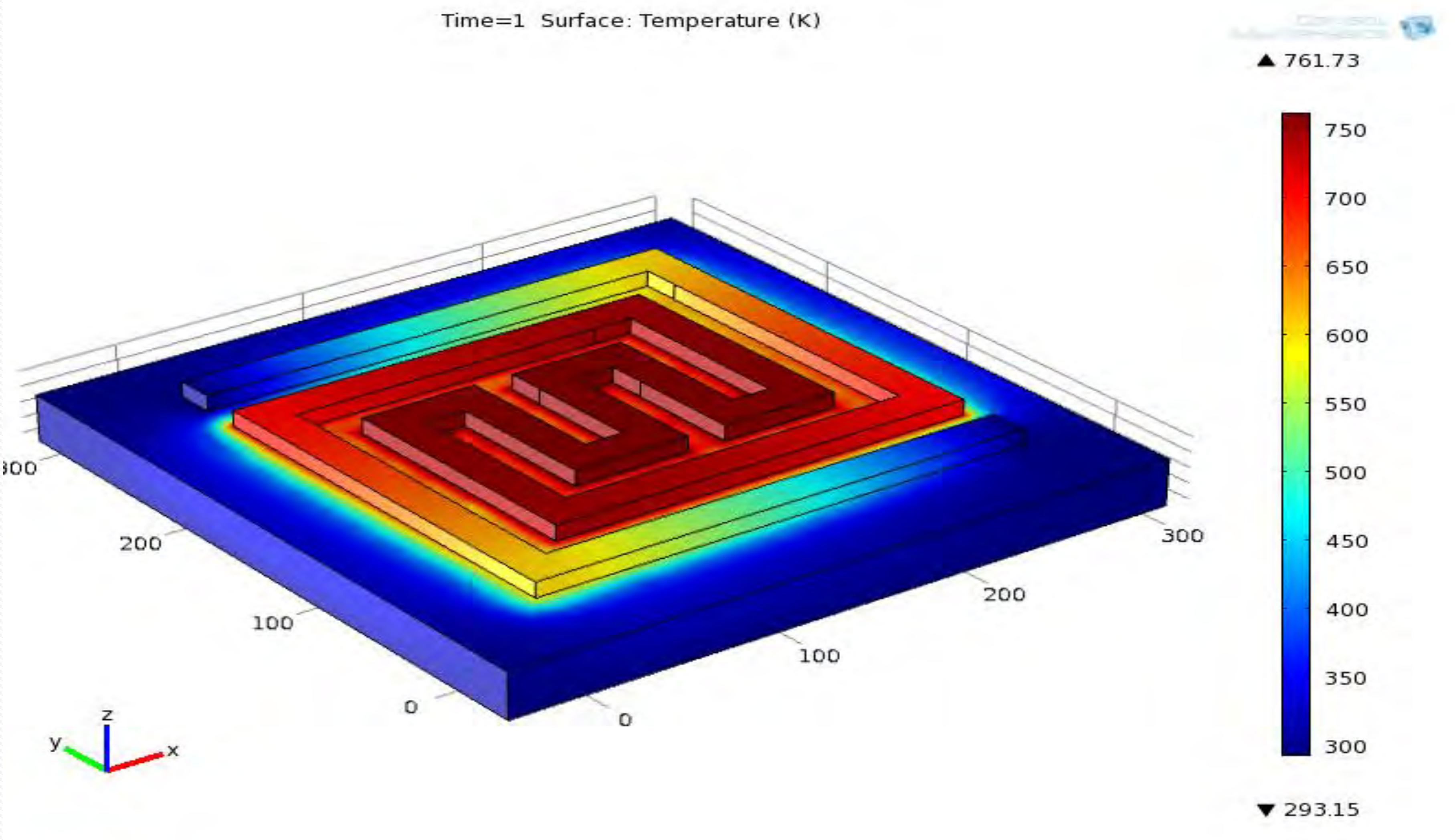
Electro Thermal Mathematical modelling of micro-heater Using Comsol 4.1

- The Joule Heating Model node in **COMSOL** uses the following version of the heat equation as the mathematical model for heat transfer in solids:

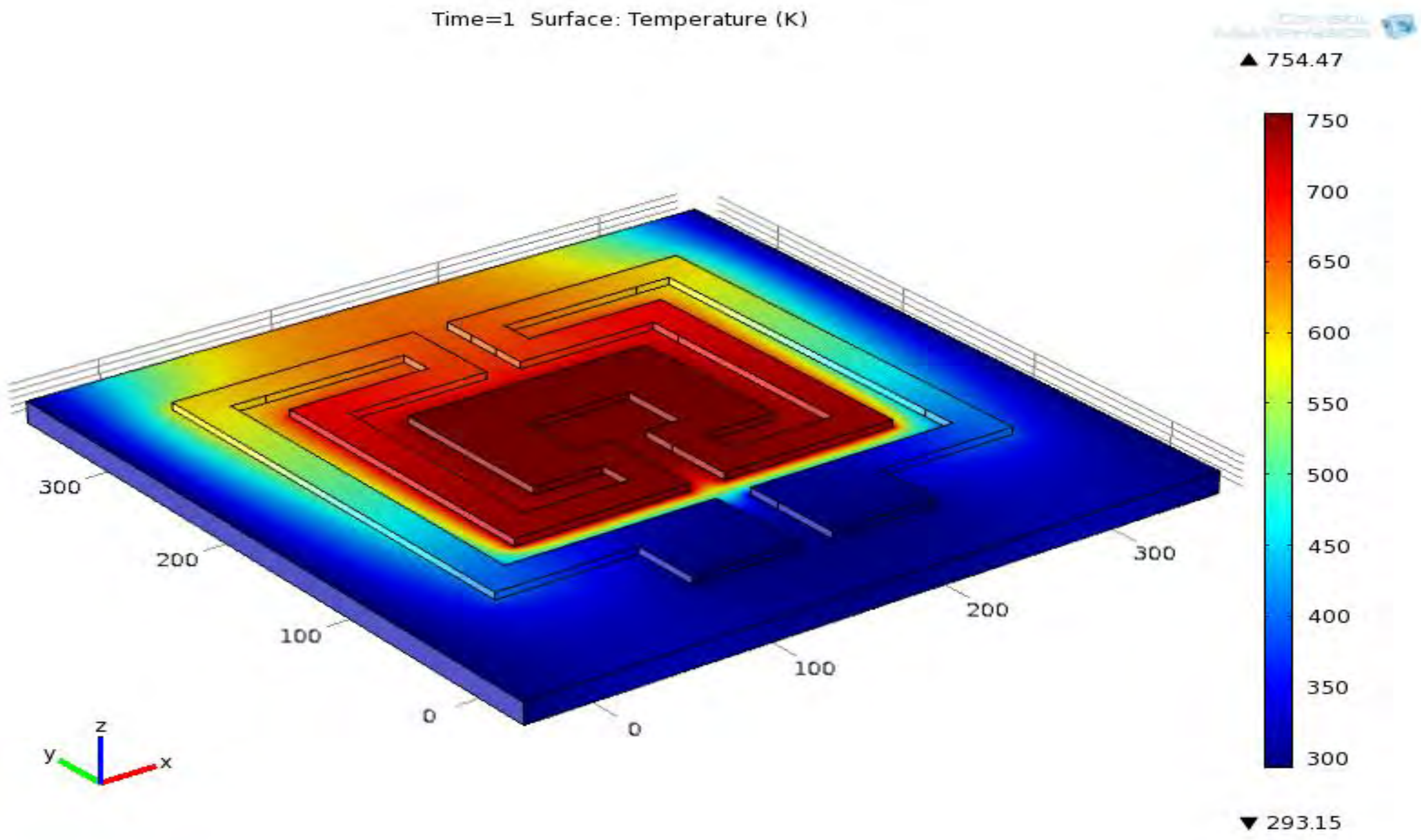
$$\rho Cp \ -\Delta.(k.\Delta T)= Q$$

- The equations have been solved under Neumann, and mixed boundary conditions numerically using the Finite Element Method (FEM) when the Electro-Thermal module is selected in COMSOL.
- The generated resistive heat Q is proportional to the square of the magnitude of the electric current density J.
- In our Simulations we assume the temperature and potential gradients in the z-direction (perpendicular to the heater plane) are equal in comparison to the gradients in x-y plane. There by taking the problems to three dimensions. This is a reasonable assumption given the relative dimensions of the structure; the thickness being much smaller than the length or width. Also Fine meshing is used for simulation.

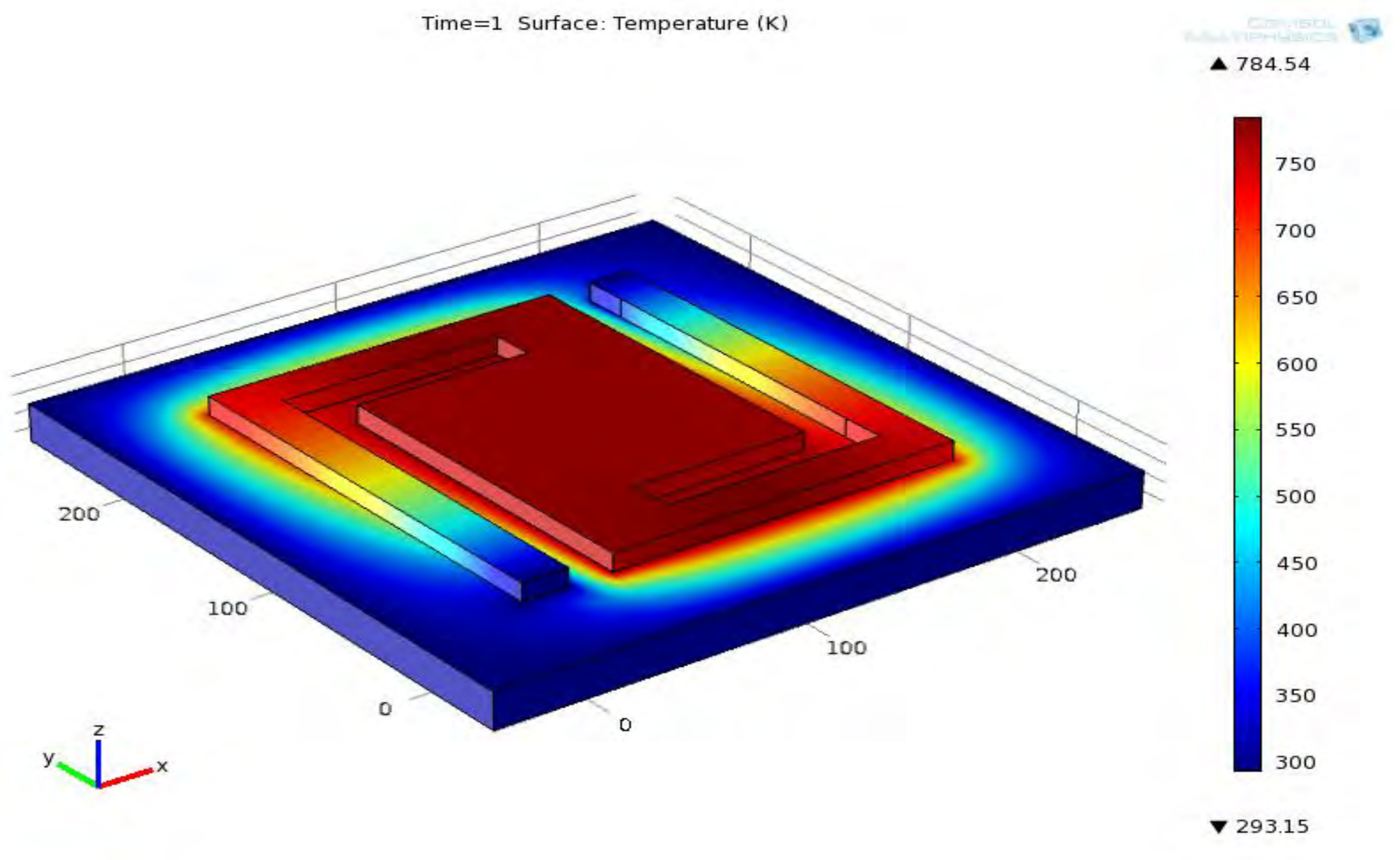
Spiral Platinum Micro-heater



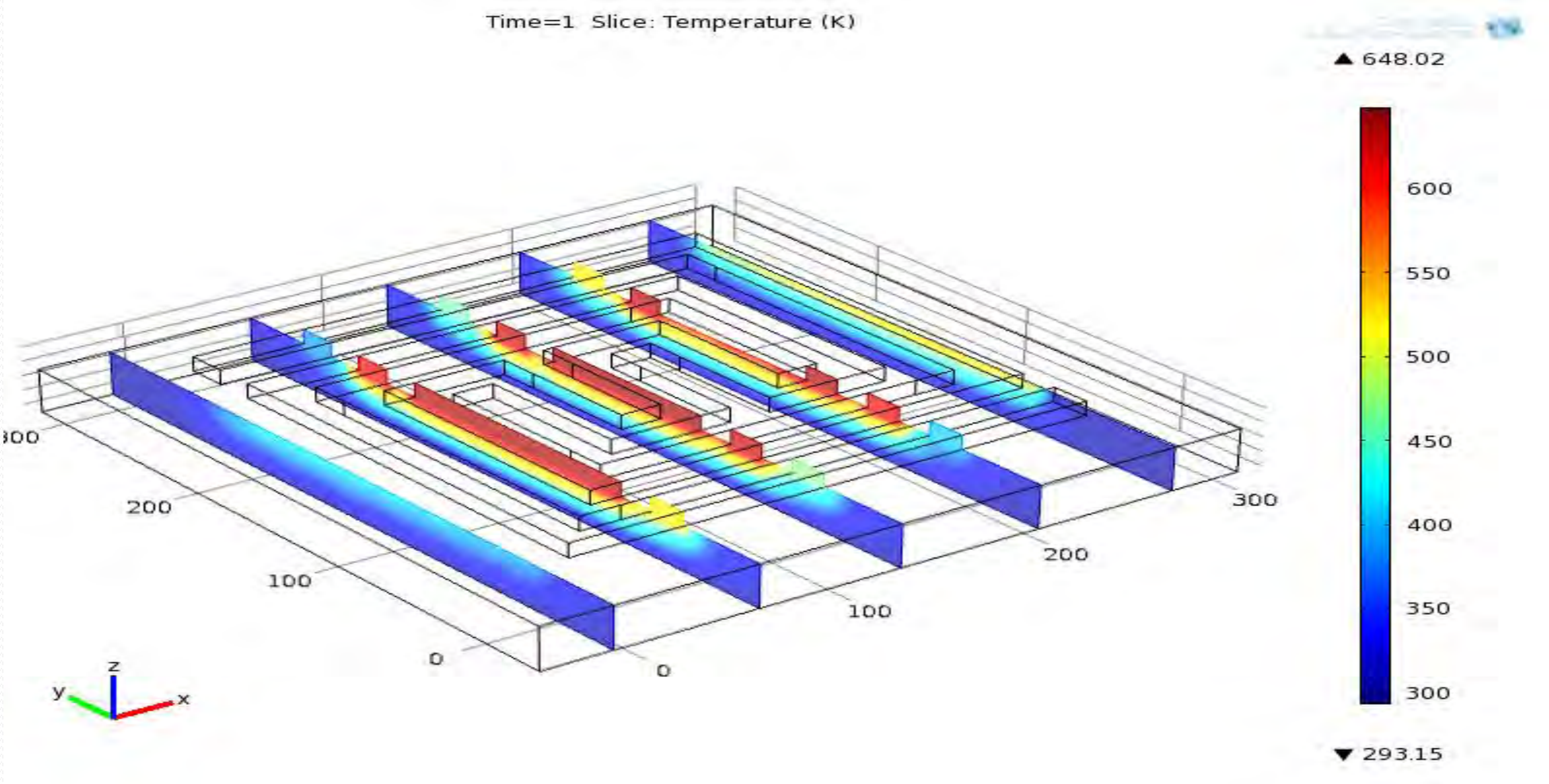
Double spiral Shaped Micro-heater



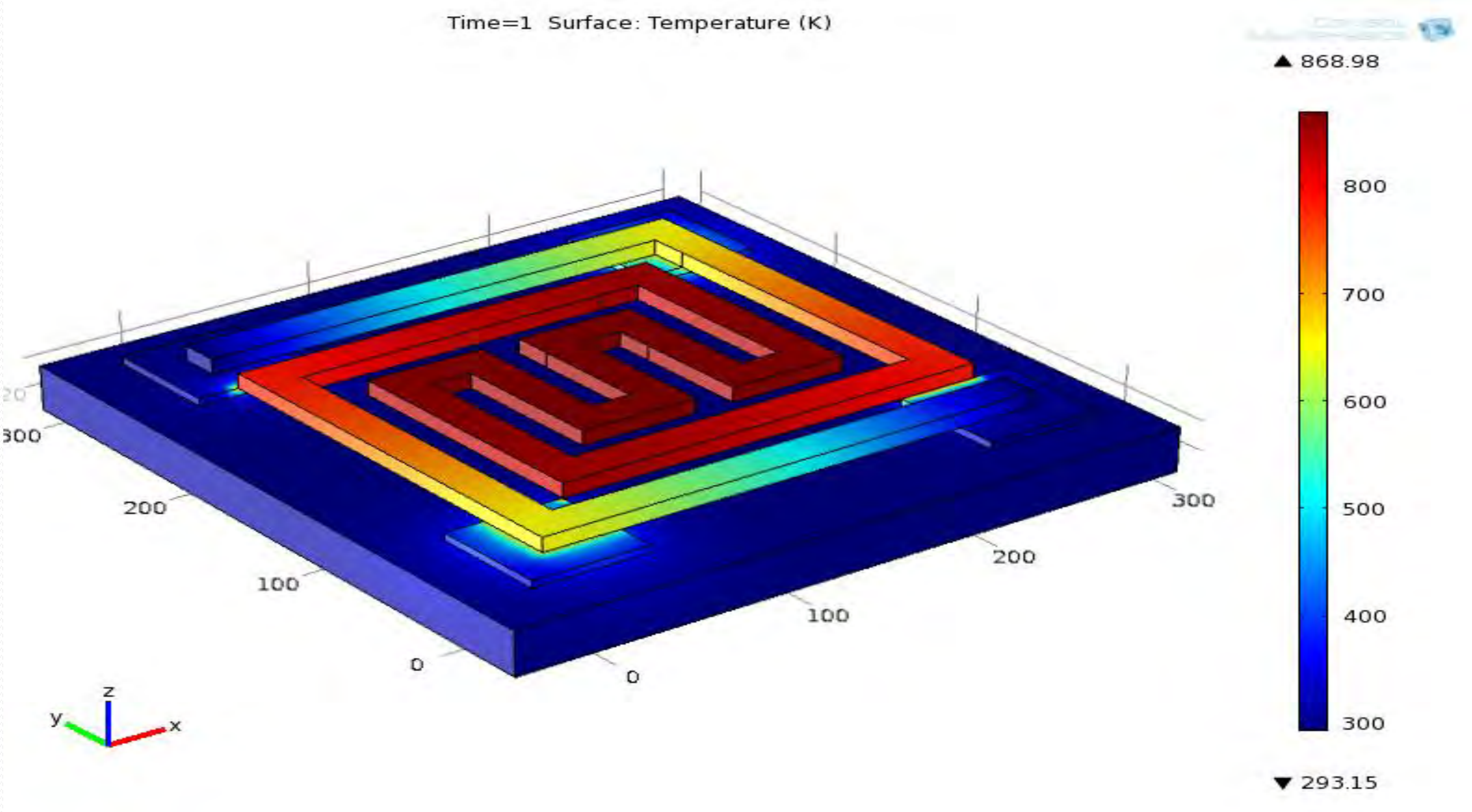
S-shaped Micro-heater



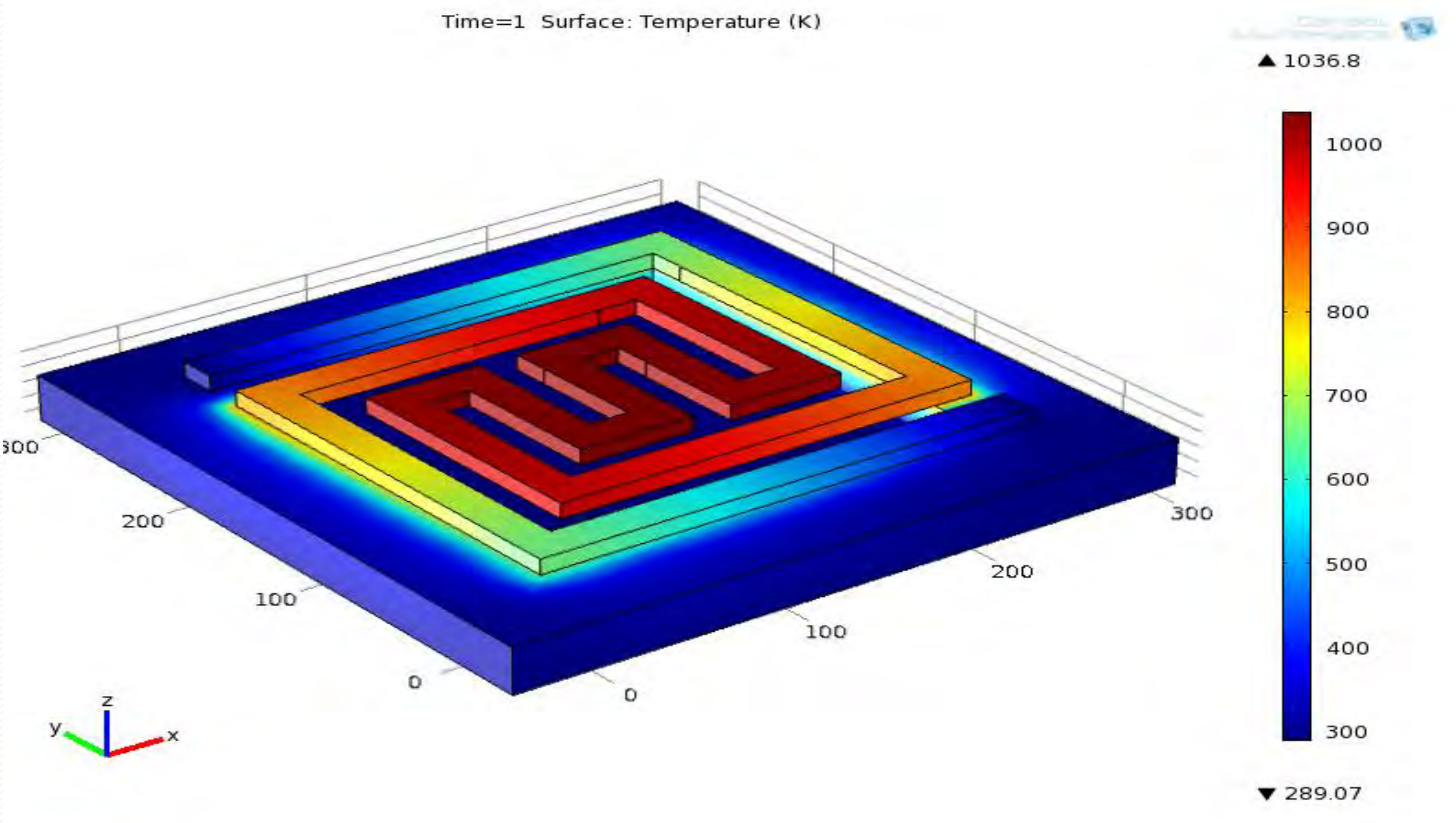
Heat dissipation in Substrate



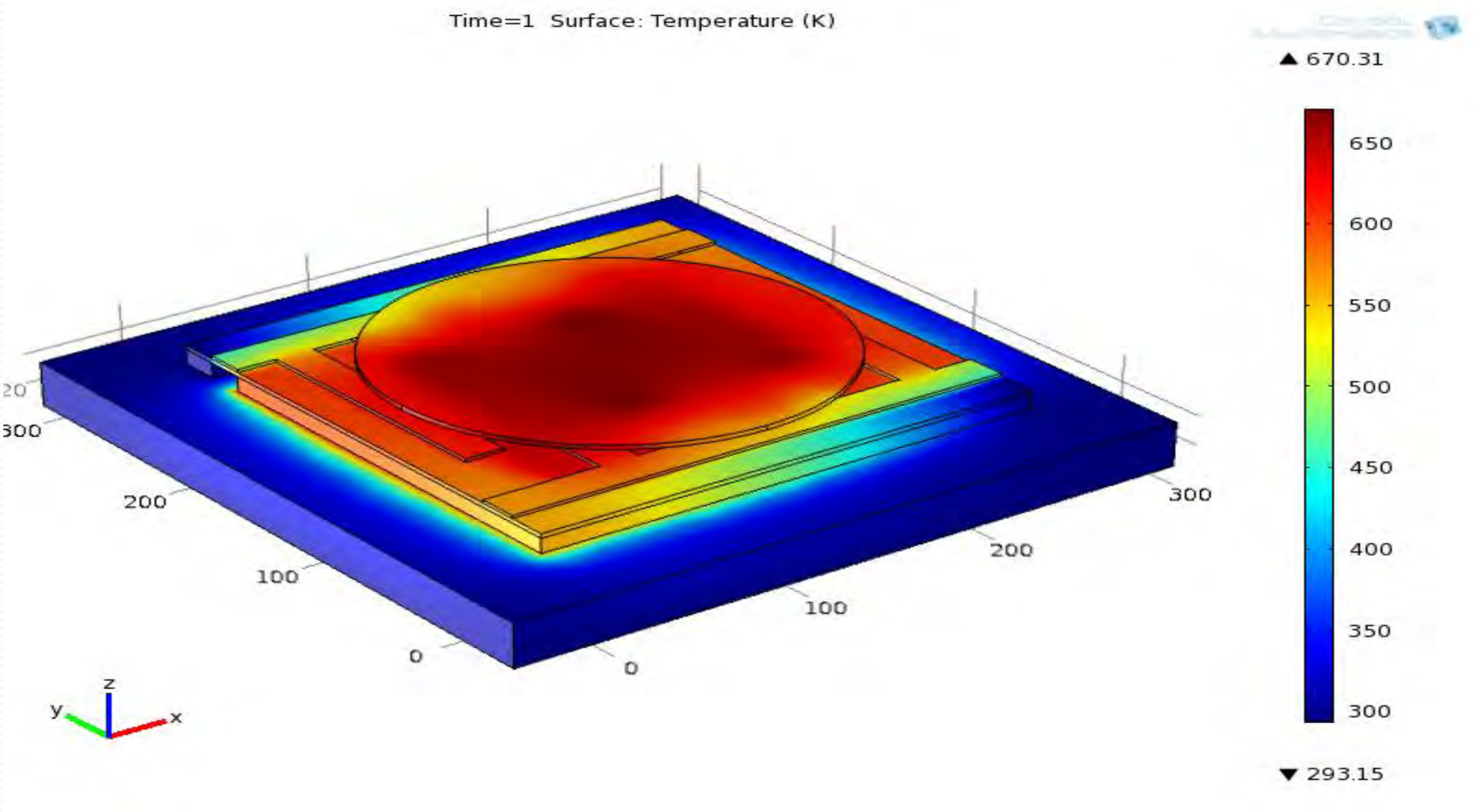
Spiral Bridged at 2V



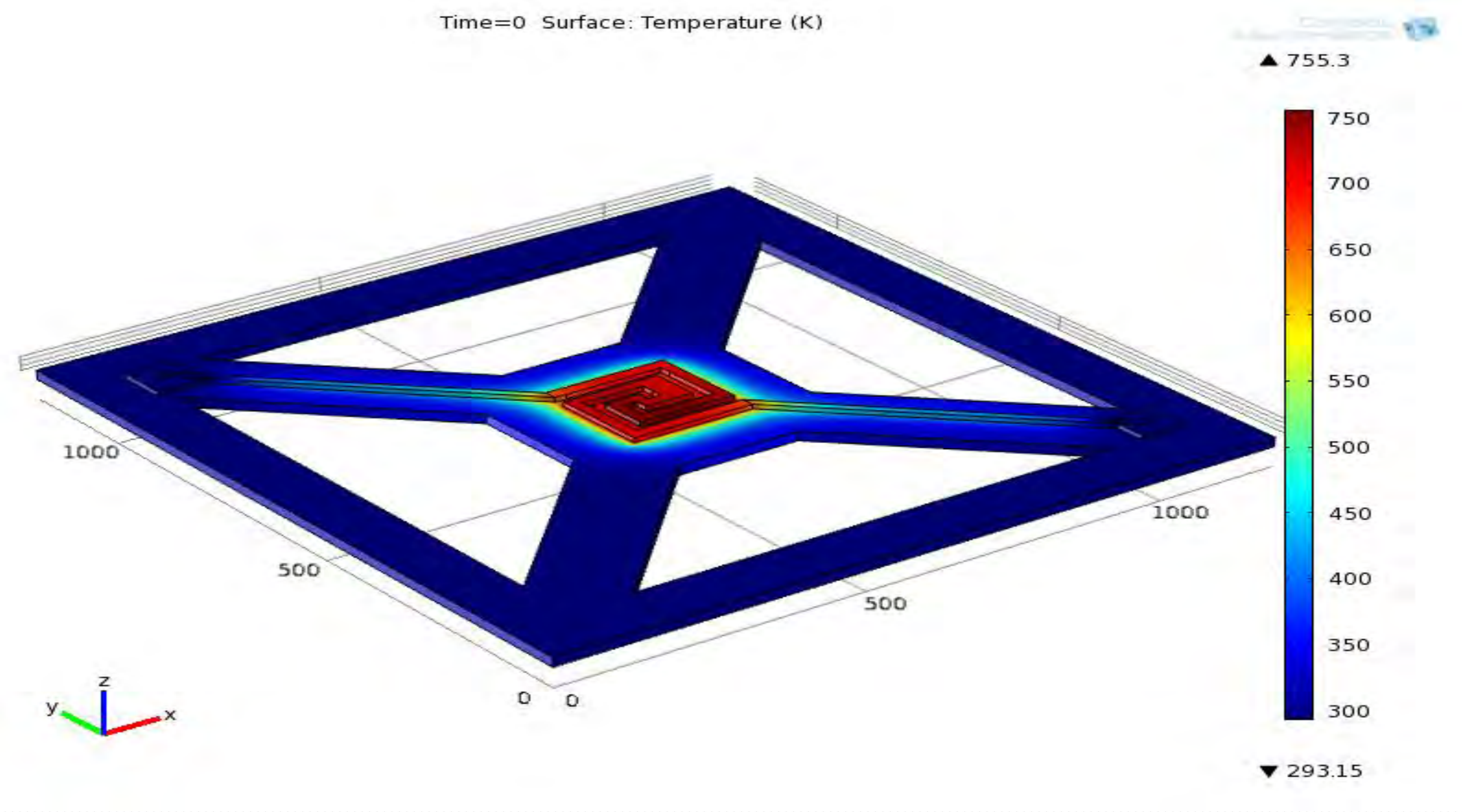
Spiral Micro-heater with Cavity



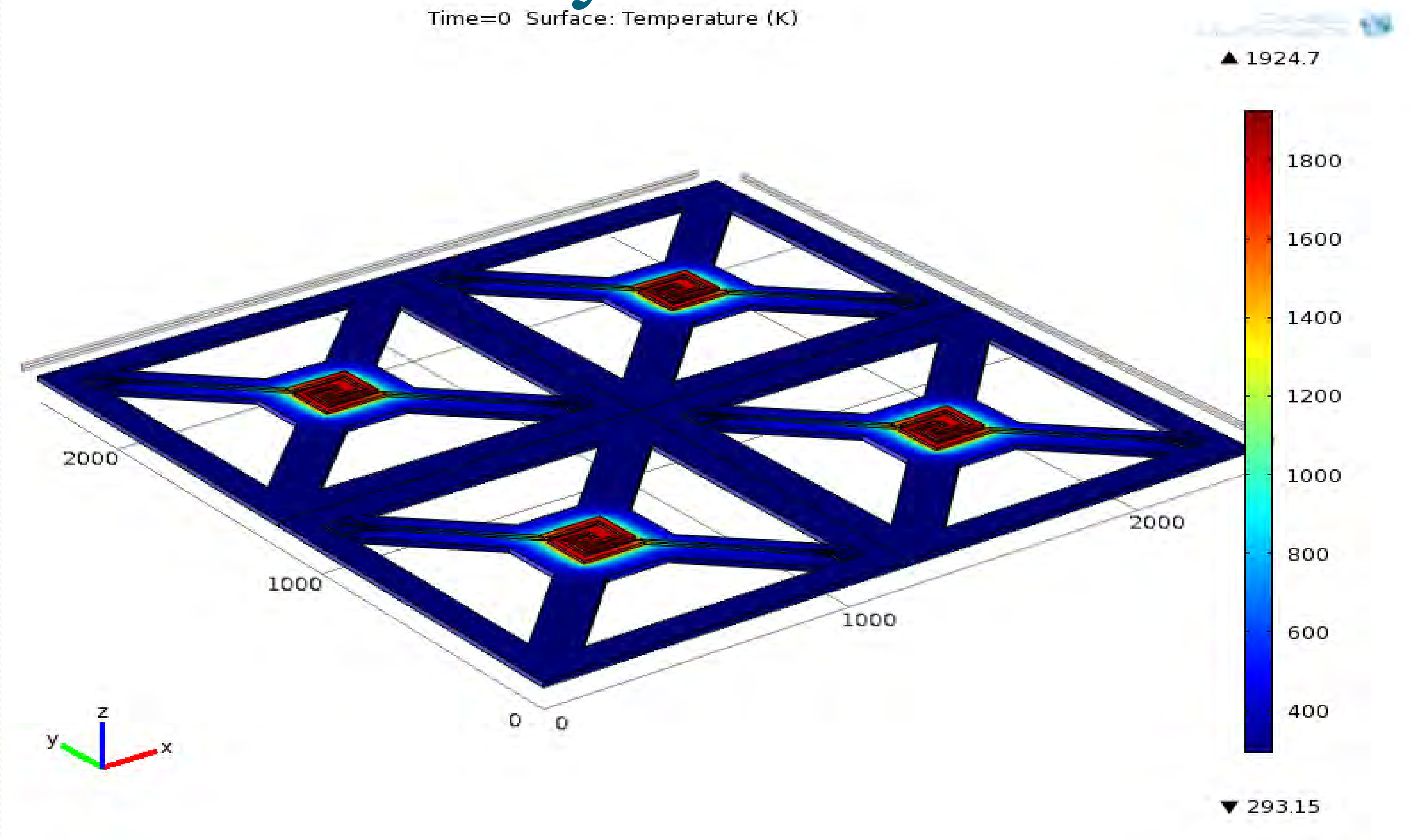
Gas sensor at operating Temp.



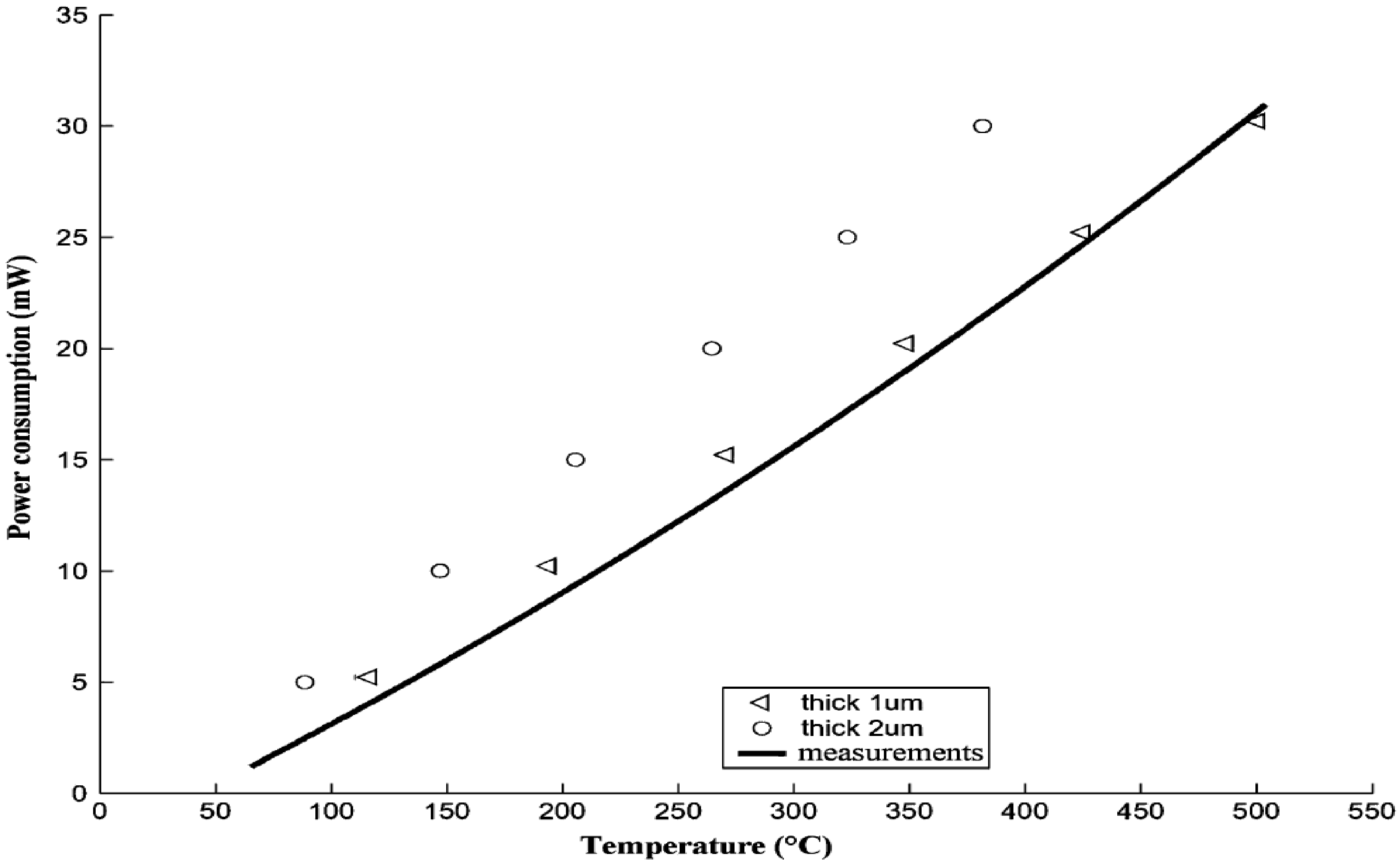
A Complete Heater at 2V



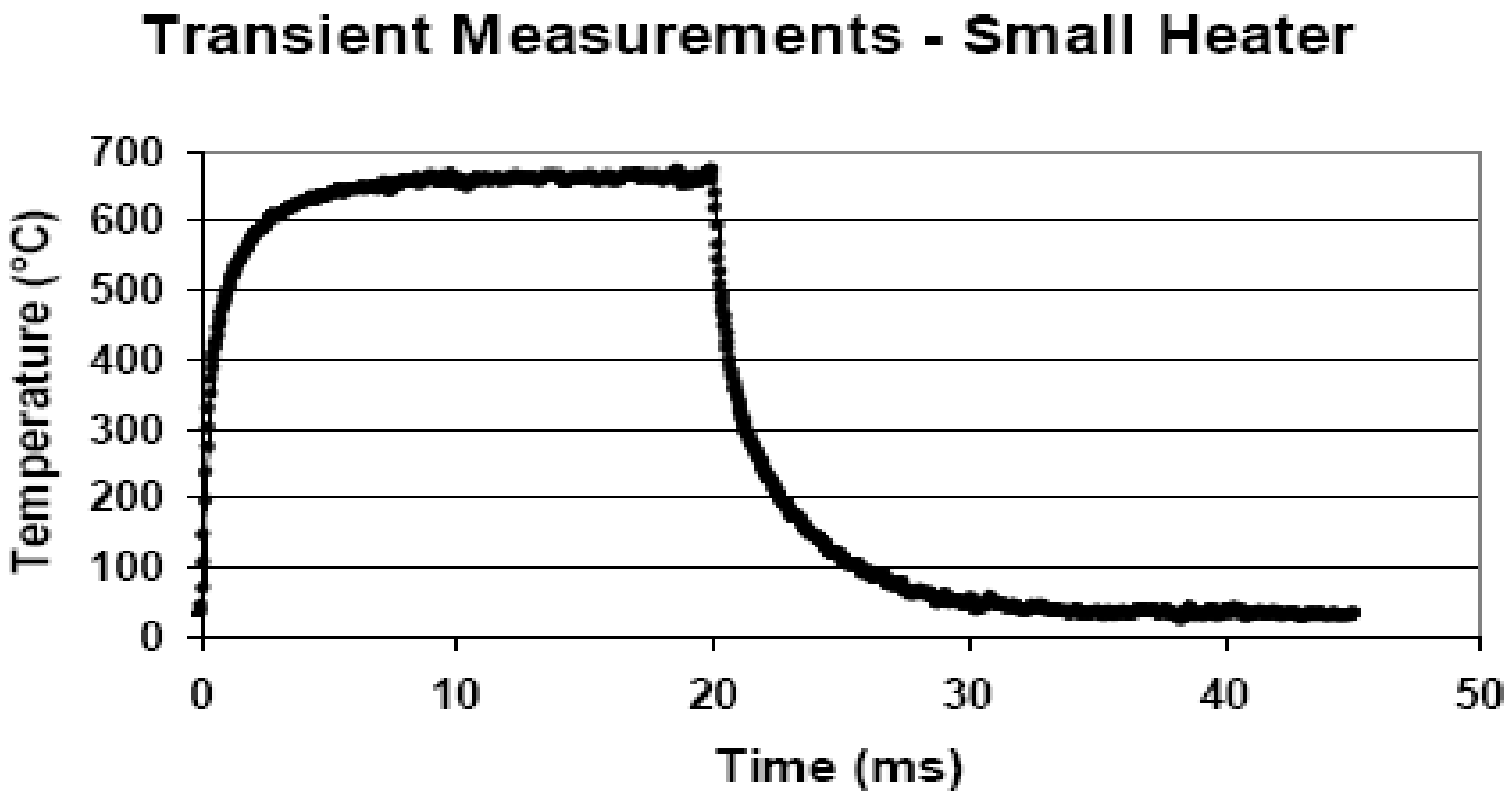
An 4×4array of Micro-heaters



Power consumption Vs Temp.



Transient Response



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Thanks