3D Stationary and Temporal Electro-Thermal Simulations of Metal Oxide Gas Sensor based on a High Temperature and Low Power Consumption Micro-Heater Structure

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Introduction: The aim of this work was to simulate the electro-thermal behavior of a micro-hotplate used as a gas sensor, in order to compare the obtained results with a real structure. The structure (Fig.1) has been designed in 3D (Fig.2) and a stationary and a temporal study has been realized.

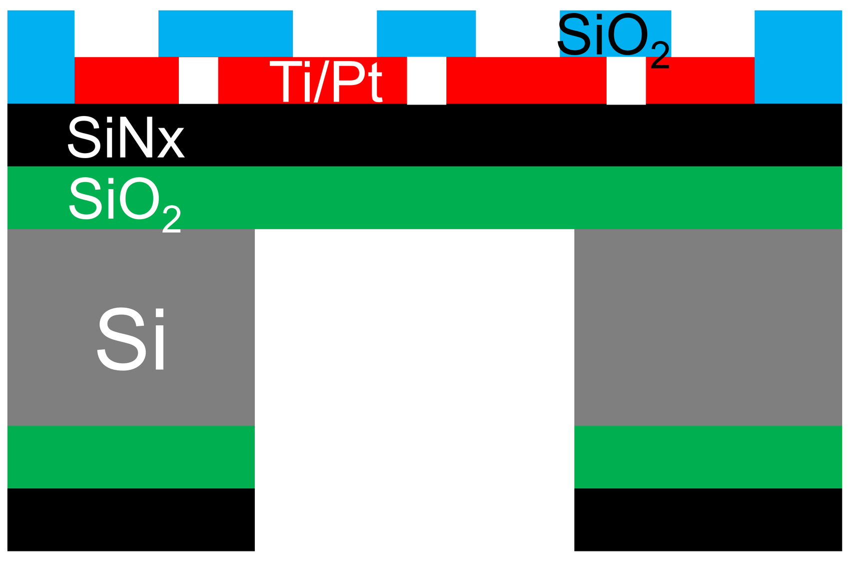

Figure 1. Micro-hotplate sectional view

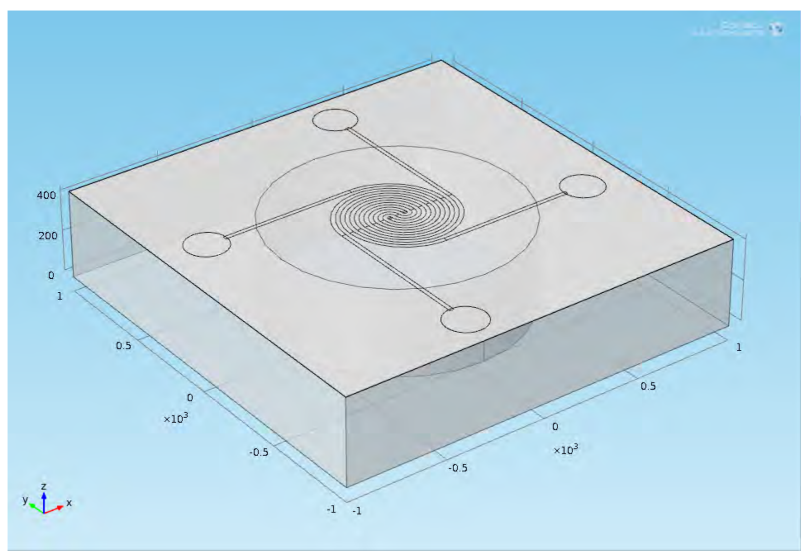

Figure 2. Micro-hotplate 3D design

Computational Methods: Joule Effect:

- Electric potential equation:

$$-\Delta.(\sigma.\Delta V) = 0$$

- Heat transfer equation:

$$Q = \rho.Cp.\frac{dT}{dt} - \Delta.(k.\Delta T)$$

Linked by:

$$Q = \sigma.|\Delta V|^2$$

Results: With the stationary study, the 3D temperature distribution has been observed (Fig.3) and the graph of the temperature versus power consumption at the surface of the micro-hotplate (Fig.4) and with different sensitive layer thickness (Fig.5) has been done.

With the temporal study, the necessary time to stabilized the structure has been deduced (thermal inertia) and the obtained value is 80ms (confirmed with electronic test) (Fig.6).

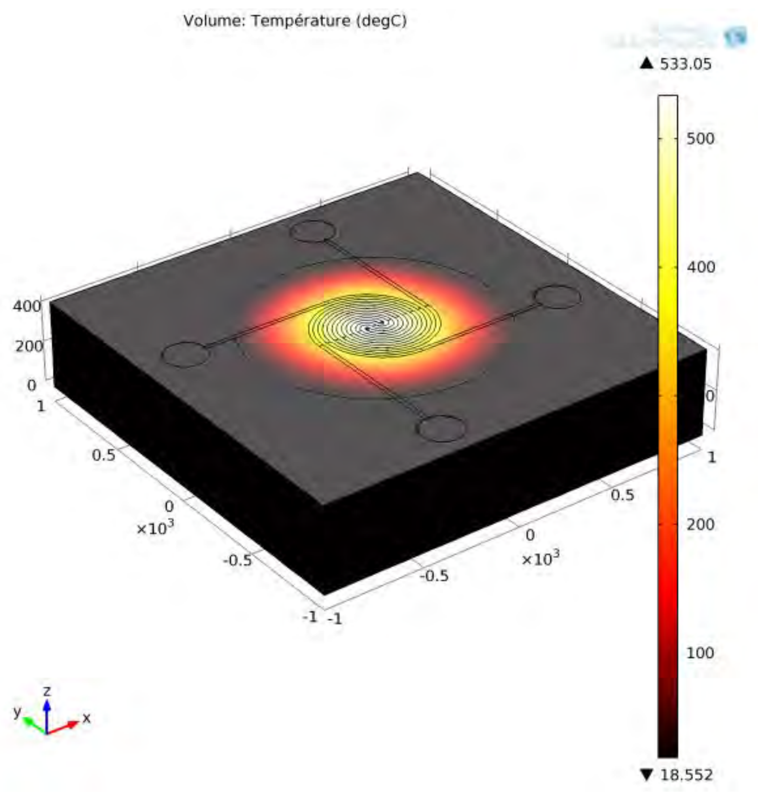

Figure 3. 3D temperature distribution - Vheater=5V

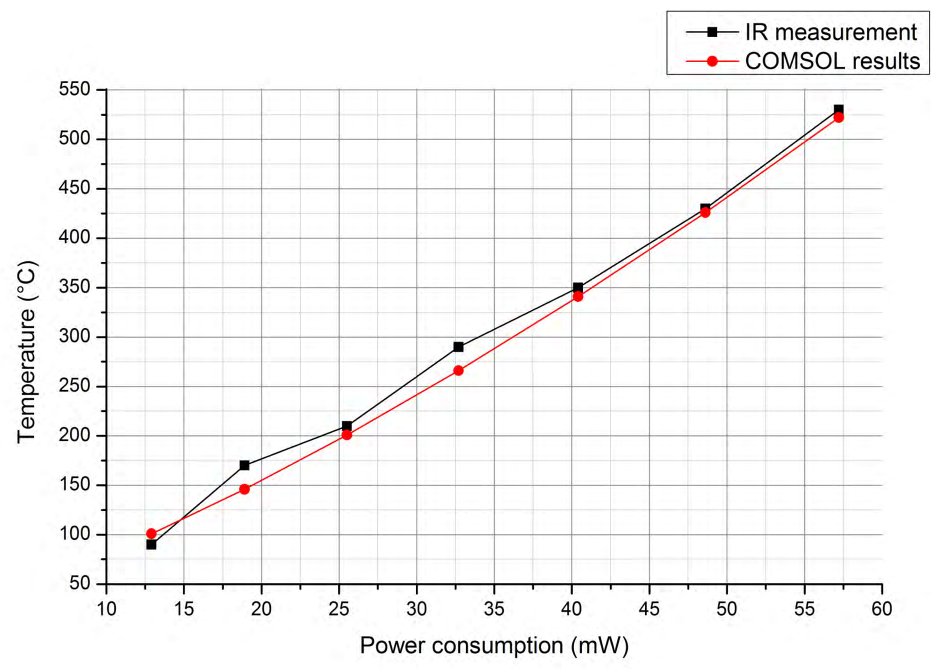

Figure 4. Temperature versus power consumption at the surface of the micro-hotplate

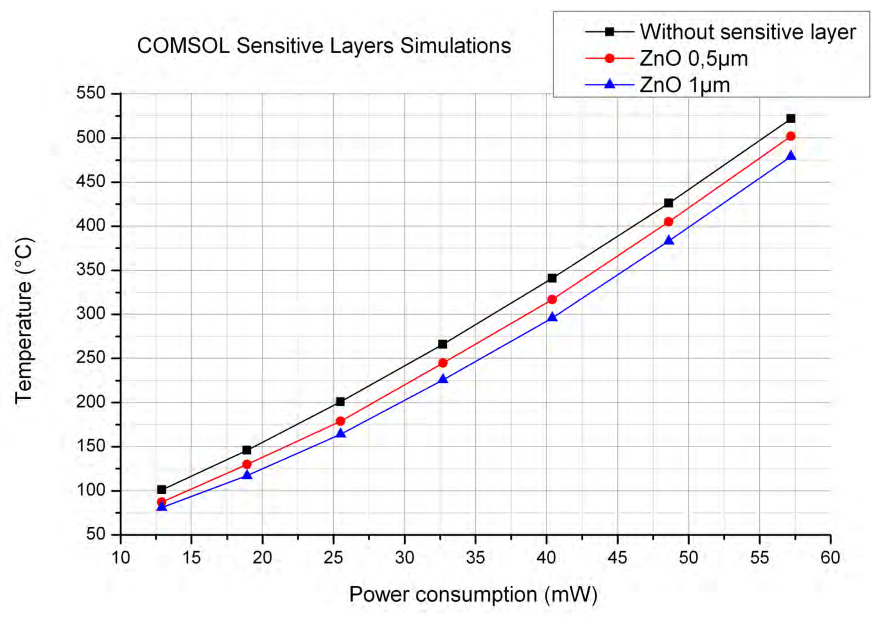

Figure 5. Temperature versus power consumption for different sensitive layer

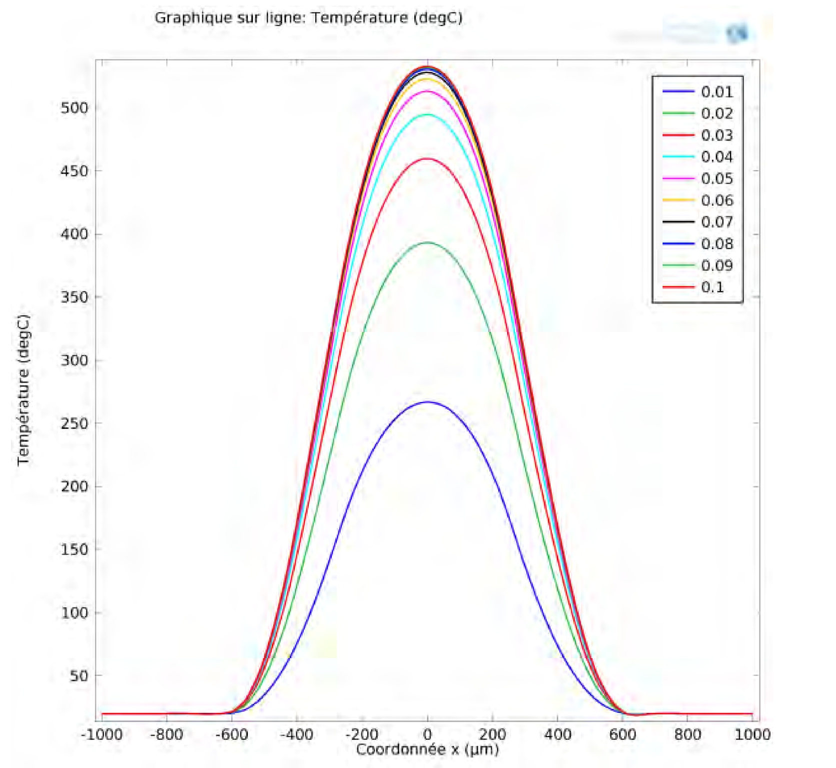

Figure 6. Temporal variations of temperature for a voltage transition between 0 and 5V

Conclusions: The results obtained with the simulated design are closed to the real component. This modeling can be used for further developments (simple cell and multi-sensor).

References:

1. K. Wetchakun & al., Semiconducting metal oxides as sensors for environmentally hazardous gases, *Sensors and Actuators B*, **160**, 580–591 (2011)
2. Alois Friedberger & al., Micromechanical fabrication of robust low-power metal oxide gas sensors, *Sensors and Actuators B*, **93,** 345-349 (2003)

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