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*Extended Abstract*

# How the Gas Flow Affects Conductometric Sensor Performance †

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## 1. Introduction

The performance of a metal oxide gas sensor can be affected by different parameters as the fabrication process of the sensitive layer or the post-annealing treatment. Nevertheless, not only the way the material has been obtained is relevant for the sensor performance. The conditions under which the detection is carried out are of great importance, namely the temperature of the material during detection and the gas flow conditions, among others.

The way the flow arrives at the sensor surface is relevant for the sensor response, mainly for the velocity of the response, but also because it can modify the temperature of the sensor. In the experiments to characterize gas sensors, the position of the gas input and output inside the sensor chamber, as well as the magnitude of the gas flow, influence the way the concentration gradient reaches the sensing material.

Moreover, convective flows are generated inside the chamber due to the sensor itself, because it acts as a heat source. As the convective flows can generate random concentration gradients, the response of the sensor will vary depending on the position of the heat source, namely, of the sensor itself.

In this work, the influence of the sensor position inside the chamber and the gas flow are analysed, comparing experimental results with flow dynamic simulations.

## 2. Simulations and Experimental

In order to investigate the effects of the position of the sensor and the flow of the gas inside the chamber during the sensing process, three cases were simulated and compared to experimental results:

i. Case I: sensor at the bottom of the test chamber and 200 sccm flow (Figure 1a)
ii. Case II: sensor at the bottom of the test chamber and 400 sccm flow (Figure 1b).
iii. Case III: sensor in the middle of the test chamber and 400 sccm flow (Figure 1c).

The temperature of the sensor heater was set at 300 °C and the analyzed pulses were 5 ppm of $NO_2$ for all the simulations and experiments.

**Simulation**: a finite volume method based on numerical fluid flow analysis was used to obtain decoupled solution for both the Navier-Stokes equations and the mass diffusion equations

(convection-diffusion equations) in the absence of reaction-transport equations and involving a high degree of convection-diffusion discretization schemes, applied to solve the combined effects of both convection and diffusion. A mass flow inlet with a mass fraction of $NO_2$ of $7.94418 \times 10^{-6}$ (5 ppm of $NO_2$) relative to air was set and atmospheric pressure was imposed in the outlet.

**Experiments**: sputtered $WO_3$ gas sensor on alumina substrate were used for the experiments. The electrical measurements were performed inside a cylindrical sealed stainless steel chamber with a volume of 0.86 l.

## 3. Results

The comparison of the simulations and the experimental results for the three different cases are shown in Figure 1, where the simulated $NO_2$ concentration arriving at the sensor (black) and the response of the sensor (blue) are plotted in the left and right axis, respectively.

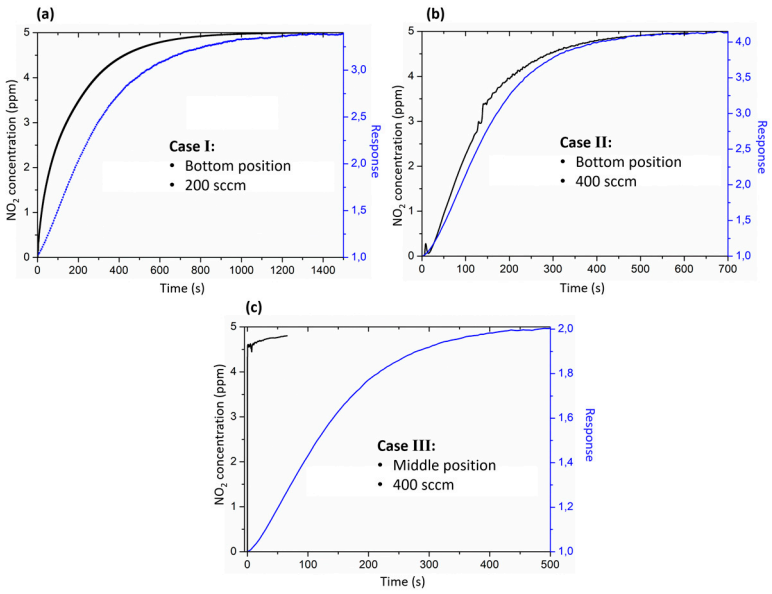


**Figure 1.** Simulated $NO_2$ concentration arriving at the sensor surface and response of the sensor for 5 ppm of $NO_2$ at 300 °C for: (**a**) at the bottom of the chamber and with 400 sccm of flow; (**b**) at the bottom of the chamber and with 200 sccm of flow and (**c**) at the middle of the chamber and with 400 sccm of flow.

For case I and II, the simulations fits the experimental data and when the flow is increased from 200 to 400 sccm, the time needed to reach the maximum concentration on the sensor surface also decreases by a factor of 2.

If the sensor is placed in the middle of the chamber and the maximum flow is used (case III), the simulations states that in less than one second more than 4.5 ppm of $NO_2$ arrive at the sensor surface and then increases more slowly up to the maximum concentration introduced in the chamber (5 ppm). By contrast, from the experimental data, the needed time to reach the maximum response is ~ 500 s (the lowest time regarding the three different cases). This substantial difference between the simulation and the experimental results in the case III could be explained by the fact that this type of sensors have a minimum response time to reach the response value. Therefore, although the desired concentration reaches the sensor surface very fast, the sensors would need at least 8 min, in this case, to reach the maximum response, probably due to the time required for the diffusion processes.

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