



**HAL**  
open science

## Sub-ppm NO<sub>2</sub> sensing in temperature cycled mode with Ga doped ZnO thin films deposited by RF sputtering

Lionel Presmanes, V Gunasekaran, Yohann Thimont, I Sinnarasa, Antoine Barnabe, Philippe Tailhades, Frédéric Blanc, Chabane Talhi, Philippe Menini

### ► To cite this version:

Lionel Presmanes, V Gunasekaran, Yohann Thimont, I Sinnarasa, Antoine Barnabe, et al.. Sub-ppm NO<sub>2</sub> sensing in temperature cycled mode with Ga doped ZnO thin films deposited by RF sputtering. 8th GOSPEL Workshop Gas sensors based on semiconducting metal oxides: basic understanding & application fields, Vincenzo Guidi, Jun 2019, Ferrara, Italy. 10.3390/proceedings2019014048 . hal-02192689

**HAL Id: hal-02192689**

**<https://laas.hal.science/hal-02192689>**

Submitted on 24 Jul 2019

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Sub-ppm NO<sub>2</sub> sensing in temperature cycled mode with Ga doped ZnO thin films deposited by RF sputtering

L. Presmanes<sup>1</sup>, V. Gunasekaran<sup>1</sup>, Y. Thimont<sup>1</sup>, I. Sinnarasa<sup>1</sup>, A. Barnabe<sup>1</sup>, Ph. Tailhades<sup>1</sup>, F. Blanc<sup>1</sup>, C. Talhi<sup>2</sup>, Ph. Menini<sup>2</sup>

<sup>1</sup> CIRIMAT, Université de Toulouse, CNRS, INPT, UPS, 118 Route de Narbonne, F-31062 Toulouse CEDEX 9, France

<sup>2</sup> LAAS-CNRS, Université de Toulouse, UPS, INSA, 7 avenue du colonel Roche, F-31031 Toulouse, France

## 1. Abstract

In this work Ga doped ZnO thin films have been deposited by RF magnetron sputtering onto a silicon micro-hotplate and their structural, microstructural and gas sensing properties have been studied. ZnO:Ga thin film with a thickness of 90 nm has been deposited onto a silicon based micro-hotplates without any photolithography process thanks to a low cost and reliable stencil mask process. Sub-ppm sensing (500 ppb) of NO<sub>2</sub> gas at low temperature (50 °C) has been obtained with promising responses R/R<sub>0</sub> up to 18.

## 2. Results

Micro-hotplates have been prepared using photolithographic process. The system is composed by a heating element and sensing electrodes. They are both integrated in membrane in order to have a localized heating and sensing spot onto which the sensitive thin film is deposited. The microhotplates can operate with low consumption and can heat up to 500 °C with a good stability. This system has been already published in [1]. The use of lift-of process to restrict the deposition of the thin film onto central electrodes can lead to the dissolution and/or contamination of the sensitive layer. That's why the photolithographic method was avoided and a stencil mask process was used (Figure 1).

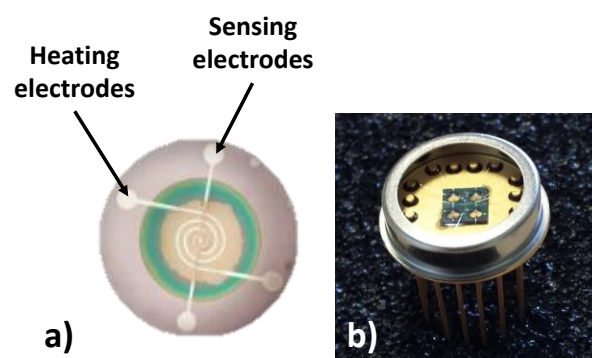


Figure 1: a) top-view of the membrane; b) mounted micro-sensor.

---

[1] L. Presmanes, Y. Thimont, I. El Younsi, A. Chapelle, F. Blanc, C. Talhi, C. Bonningue, A. Barnabé, Ph. Menini, and Ph. Tailhades, "Integration of P-CuO Thin Sputtered Layers onto Microsensor Platforms for Gas Sensing", *Sensors*, vol. 17, #1409, June 2017.

The deposition conditions are shown in the Table I.

Table I: *Deposition parameters of ZnO:Ga thin film by RF-sputtering.*

Target material	ZnO:Ga
Power (W)	(4 %at)
Magnetron	30
Argon pressure P (Pa)	Yes
Target to substrate distance	2
d (cm)	7

The measurement protocol used in the test bench is a cycle of heating and cooling steps from 5 mW to 35 mW with a step of 5 mW for 5 min which correspond approximately to 50 °C to 350 °C. The tests were performed with 50% relative humidity. Alternation of air and air with 500 ppb of NO<sub>2</sub> has been applied. In presence of air, the resistance is very low, close to 300 Ω, due the high conductivity of ZnO:Ga. When 500 ppb of NO<sub>2</sub> are injected, the resistance increases strongly up to 7 kΩ at 50 °C. The ratio R/R<sub>0</sub> (where R is the resistance under NO<sub>2</sub> and R<sub>0</sub> the resistance under air) has been calculated using the last points at each temperature step (Figure 2).

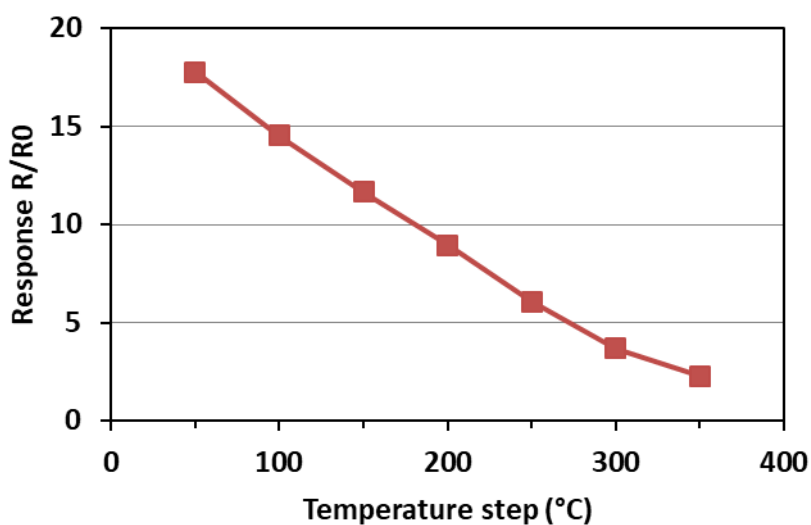


Figure 2: *Response of ZnO:Ga vs temperature step (in cycled temperature mode).*

Unlike the results we obtained in isothermal mode, the response in cycled temperature mode is much higher close to room temperature. Promising results with a response up to 18 for 500 ppb of NO<sub>2</sub> at 50 °C (R/R<sub>0</sub> ~ 36 /ppm) have been highlighted.

### 3. Acknowledgement

This work has received funding from the Program Interreg-Sudoe of the European Union under grant agreement SOE2/P1/E0569 (NanoSen-AQM). This work was also partly supported by the French RENATECH network through technology developments in the CNRS-LAAS cleanroom