proceedings

Abstract

Sub-ppm NO_2 Sensing in Temperature Cycled Mode with Ga Doped ZnO Thin Films Deposited by RF Sputtering †

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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 50 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_2 gas at low temperature (50 °C) has been obtained with promising responses R/R0 up to 18.

1. 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).

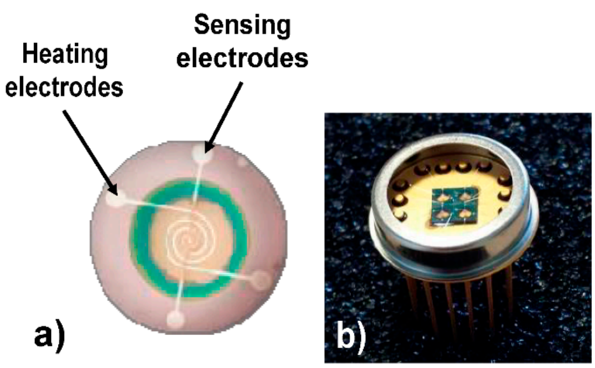

Figure 1. (**a**) top-view of the membrane; (**b**) mounted micro-sensor.

The deposition conditions are shown in the Table 1.

Table 1. 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_2 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_2 are injected, the resistance increases strongly up to 7 kΩ at 50 °C. The ratio R/R0 (where R is the resistance under NO_2 and R0 the resistance under air) has been calculated using the last points at each temperature step (Figure 2).

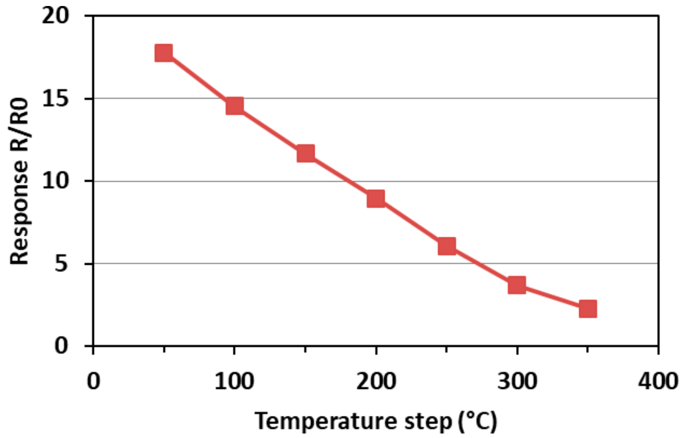

Figure 2. Response of ZnO:Ga vs. temperature step (in cycled temperature mode).

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_2 at 50 °C (R/R0 ~ 36/ppm) have been highlighted.

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