PSPICE SIMULATION MODEL OF SELECTIVE HYDROGEN GAS NANOSENSOR USING INDIVIDUAL ZNO NANOWIRE WITH FAST RESPONSE AT ROOM TEMPERATURE

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Abstract: *In this work is presented PSpice circuit model of selective hydrogen gas nanosensor using individual ZnO nanowire with fast response at room temperature. The sensor model depicts the dynamic response of the nanosensor to 100 ppm gas concentration at room temperature and influence of the UV irradiation. The model has been implemented using Cadence software student version, and is based on the physical and chemical proprieties of the sensing material. Was created subcircuit file SUBCKT what was included in the library of PSpice program.*

Keywords: *Gas Nanosensor , PSpice model , Equivalent circuit.*

1. Introduction

The development of higly sensitive, selective, reliable, and compact sensing devices to detect flammable, toxic, chemical and biological agents is of major importance. In order to overcome some ctritical limitations of gas response to low concentration of tested gases different types of nanostructured materials and approaches have been investigated for their gas response, selectivity and possible application in sensor with better characteristics. However, to integrate such nanosensors with driving circuits and to simulate it is important to develop SPICE model.

PSpice models make easy to study characteristics of sensors and can be used to create efficient applications. This model is based on the physical and chemical proprieties of the sensing material.

The main feature of the PSpice models presented here is that they can simulate nanosensor dynamics, either when the gas concentration and UV iradiations are modulated using arbitrary functions (concentration pulses).

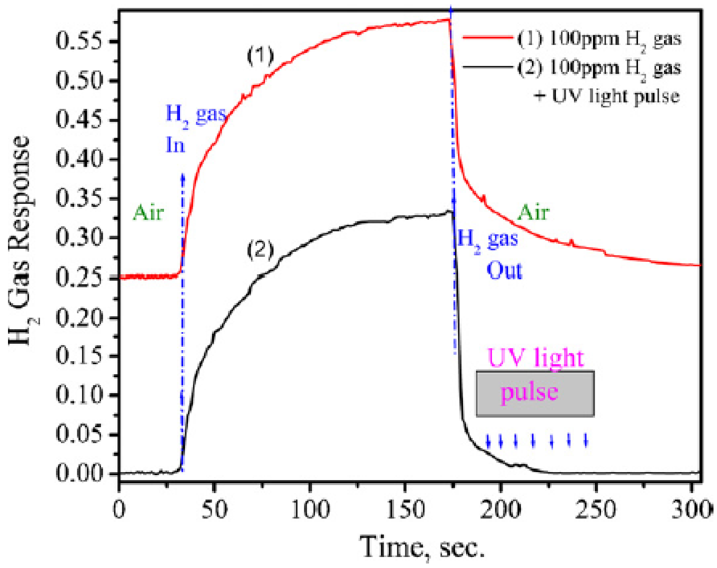

Fig. 1. Gas response curves of the 100 nm zinc oxide nanowire-based gas sensor under exposure to 100 ppm of H_2 gas at room temperature (22 °C). Curve (1) is displaced upward by 0.25 to avoid overlapping with curve (2) [1].

In work [1] was developed and studied the gas response and selectivity of ZnO nanowires to H_2, NH_3, i-Butane, CH_4 gases at room temperature. According experimental results as can be seen from fig. 1 gas response of ZnO nanowire is a curve. UV radiaton procedure is used to facilitate desorption of gas species on the surface and to improve the recovery time of the nanosensor. Fig. 1 (curve 2) demonstrate that the recovery time of the UV radiated sensor is much shorter than that of curve 1 (fig. 1)

In present report is developed PSpice simulation model of selective H_2 gas nanosensor.

2. Experimental

In fig. 2 is represented a developed bloc diagram, schematic view of the nanosensor and the potential divider circuit used to test the nanosensor [2]. For simulation purposes and simplicity reasons, a voltage source emulates the gas concentration where it is assumed that 1 V corresponds to 1 ppm of gas concentration. For instance, the injection of 100 ppm of H_2 can be simulated by supplying a d.c. voltage of 100 V. R indicates the output voltage corresponding to the nanosensor resistance (1 V = 1 Ω).

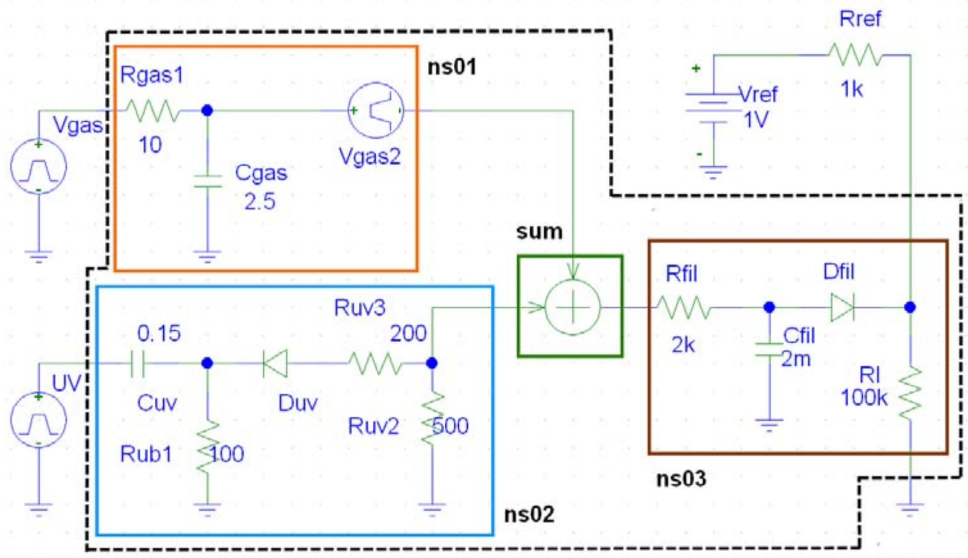

Fig. 2 Bloc diagram and schematic view of the nanosensor Pspice model and the potential divider circuit used to test the nanosensor in simulation process.

The block ns01 simulated gas transfer (Vgas) behavior is also included in the model, the block ns02 simulated UV irradiation (UV), the block sum evaluate response as a function of the gas concentration and UV irradiation, the block ns03 emualtes the dynamic sensor response to gas pulses.

3. Simulation results

On the base of equivalent circuit shown on fig. 2 was created subcircuit file SUBCKT and included in the library of PSpice program:

```
*Subcircuit of gas nanosensor
*                      Gas concentration (1 ppm = 1 V)
*                      |   UV irradiaton
*                      |   |   Vout
*                      |   |   |
.subckt GAS_NANOSENSOR 100 200 300 500; - GND
*Block ns01
Rg1  100 11 {R_gas}
Cgas  11  0 {C_gas}
Vgas2 11 13 PULSE(0V {V2*0.5} {TD+PW} {T} {PER-PW+TD}{(PER-PW+TD)*0.1}
{PER})
```

```
*Block ns02
Cuv   200  21  {C_UV}
Ruv1   21   0  {R_UV}
Ruv2   23   0  {R_UV*5}
Ruv3   22  23  {R_UV*2}
Duv    22  21  DIODE
*Block sum
E_SUM1 41 0 VALUE {V(23)+V(13)}
*Block ns03
Rfil   41   42  {R_fil}
Cfil   42   0   {C_fil}
Dfil   42   300  DIODE
Rload  300  0  {R_fil*50};
.MODEL DIODE D(RS=10m CJO=0.1pF N=0.001)
.ends GAS_NANOSENSOR
*----------------------------------------------------------------------
```

In the simulation a d.c. voltage of 1 V is applied to the input. A voltage divider configuration has been chosen here in order to convert the nanosensor resistance into a voltage that can be further processed, amplified or interfaced to other devices. Gas injection and UV irradiation are simulated by voltage sources. Results of simulation is represented in fig. 3.

```
PSPICE MODELING OF SELECTIVE GAS NANOSENSOR USING INDIVIDUAL ZnO nanowire
at room temperature
*PARAMETERS
.PARAM UV=50;                  UV source
.PARAM TD=10s;                 the delay from time zero of the first
*                              rising edge of Vgas
.PARAM PW=100s;                pulse width Vgas
.PARAM PER=145s;               period Vgas
.PARAM V2=100V;                gas concentration 1V=1ppm
.PARAM T=1u;                   rise and fall time
.PARAM C_gas=2.5;              capacitance from block ns01
.PARAM C_UV=0.15;              capacitance from block ns02
.PARAM C_fil=2m;               capacitance from block ns03
.PARAM R_gas=10;               resistance from block ns01
.PARAM R_UV=100;               resistance from block ns02
.PARAM R_fil=2k;               resistance from block ns03
*D.C. voltage Vref1
Vref   2  0  DC 1V
Rref   3  2  1k
*D.C. voltage Vref2
Vref2   31   0  DC 1V
Rref2   33  31  1k
*GAS source
Vgas 100  0  PULSE(0V {V2} {TD} {T} {T} {PW} {PER})
*UV source
Vuv  200  0  PULSE(0V {-UV} {TD+PW} {T} {T} {PER-PW} {PER})
*----------------------------------------------------------------------
.lib E:\nanosensorgas.lib
x1  100  200  3   0  GAS_NANOSENSOR;
x2  100  0    33  0  GAS_NANOSENSOR;
.TRAN  0ns  300s
.PROBE v(33) , v(3) , v(Vgas)
*----------------------------------------------------------------------
.END
```

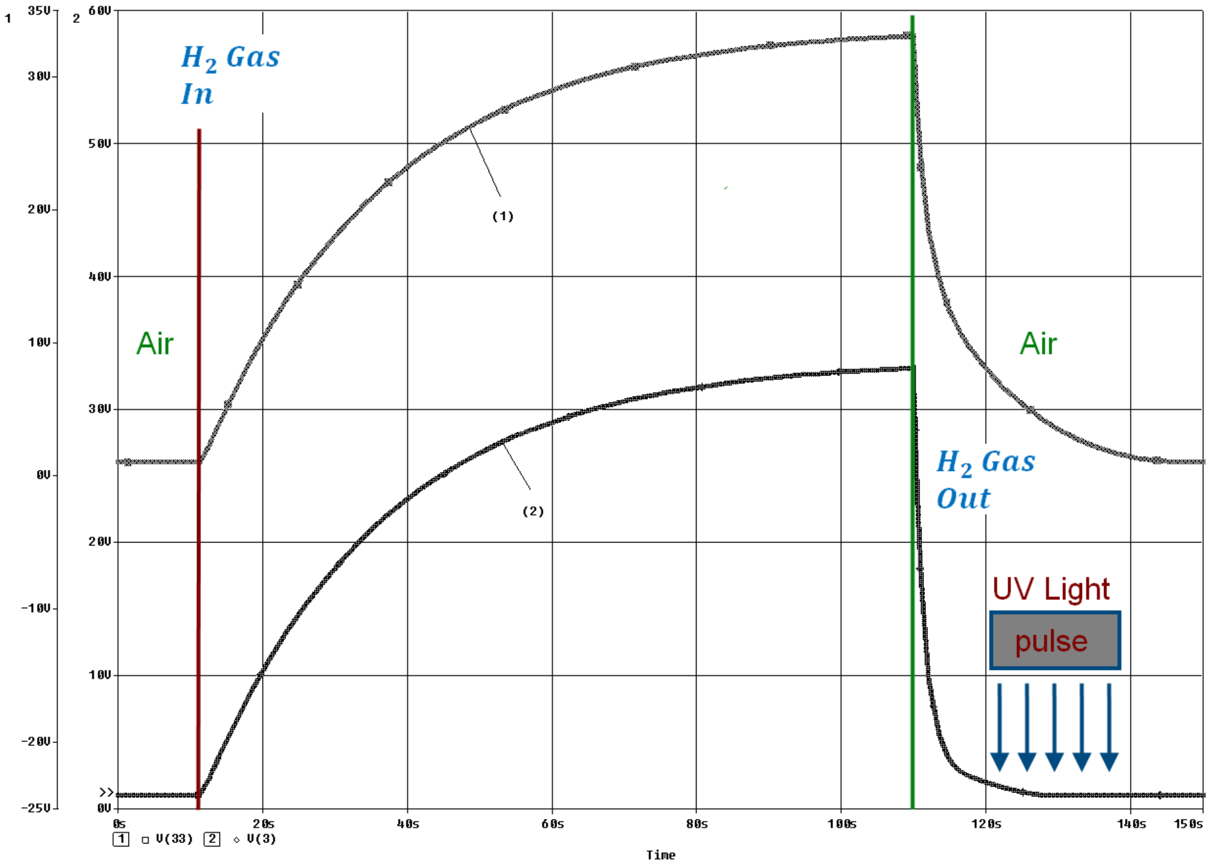

Fig. 3 Results of simulation gas nanosensor PSpice model. (1) 100 ppm H_2 gas, (2) 100 ppm H_2 gas + UV light pulse Curve (1) is displaced up to avoid overlapping with curve (2).

4. Conclusions

Results of the present work is developed PSpice circuit model of gas nanosensor. Was demonstrated that results are in good agreement with the experminetal data. Proposed model can be used in studying of gas nanosensor using individual ZnO nanowire with fast response at room temperature in different circuit with PSpice models.

References:

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