PSPICE SIMULATION MODEL OF AN INDIVIDUAL ZNO MICROWIRE-BASED UV PHOTODETECTOR

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Abstract*: In this work is presented PSpice circuit model of an individual ZnO microwire-based UV photodetector that was developed and studied in work [1]. The photodetector model depicts the transient response to UV light (365 nm) and variation of the electrical resistence of ZnO microwire-based detector in the dark and under UV illumination for different RH values. 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: *ZnO Microwire, Photodetector, UV , PSpice model , Equivalent circuit.*

1. Introduction

In the past decade, ultraviolet rays reaching the earth's surface have intensified due to increasing stratospheric ozone depletion, and they may cause adverse effects on the human body, like high skin cancer rates, etc.

In this connection there is a strong motivation for the development of small, low-cost, robust, and efficient UV detectors able to work in diverse conditions and that can be installed in different customer electronic devices easily. However, to integrate such detectors with driving circuits and to simulate it is important to develop SPICE model.

The model has been implemented using Cadence software student version. 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 [1].

The main feature of the PSpice models presented here is that they can simulate photodetector proprietes, either when the UV iradiations and relative humidity are modulated using arbitrary functions.

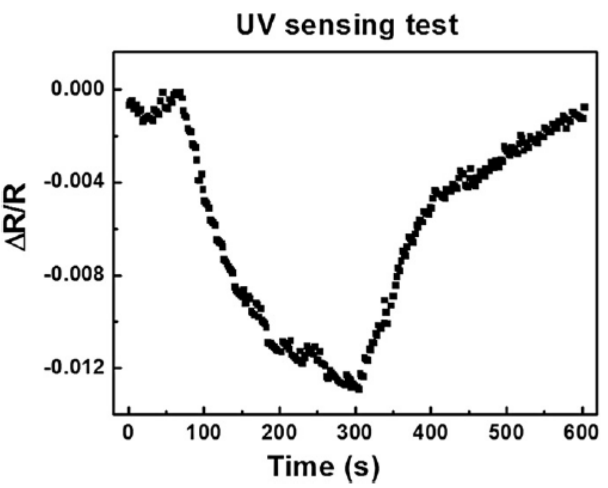

Fig. 1. UV sensivity measurement of the fabricated single ZnO microwire device structure [1].

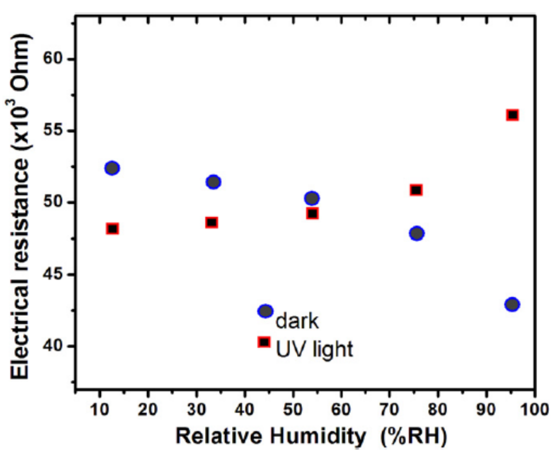

Fig. 2. Dependence of the electrical resistance versus relative humidity in the dark and under UV light

In Fig. 1 the device was subjected to irradiation with 365 nm UV light in ambient air with electrical resistance monitoring. The background atmosphere was ambient air with relative humidity (RH) of 53%.

Fig. 2 presents the variation of the electrical resistence of ZnO microwire-based detector in the dark and under UV illumination for different RH values.

2. Experimental

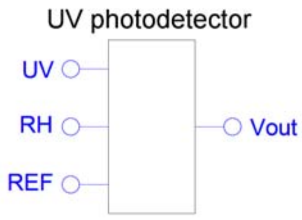

Fig. 3 Simplified Pspice model of UV photodetector as a four-terminal device, employing voltage sources for emulating UV light, setting of RH and voltage reference.

In fig. 4 is represented a developed bloc diagram and schematic view of the UV photodetector. For simulation purposes and simplicity reasons, a voltage source emulates the UV irradiation where it is assumed that 1 V corresponds to 1 eV. The relative humidity RH is simulated by supplying a d.c. voltage. The output voltage indicates electrical resistance ratio (1 V = 1 %).

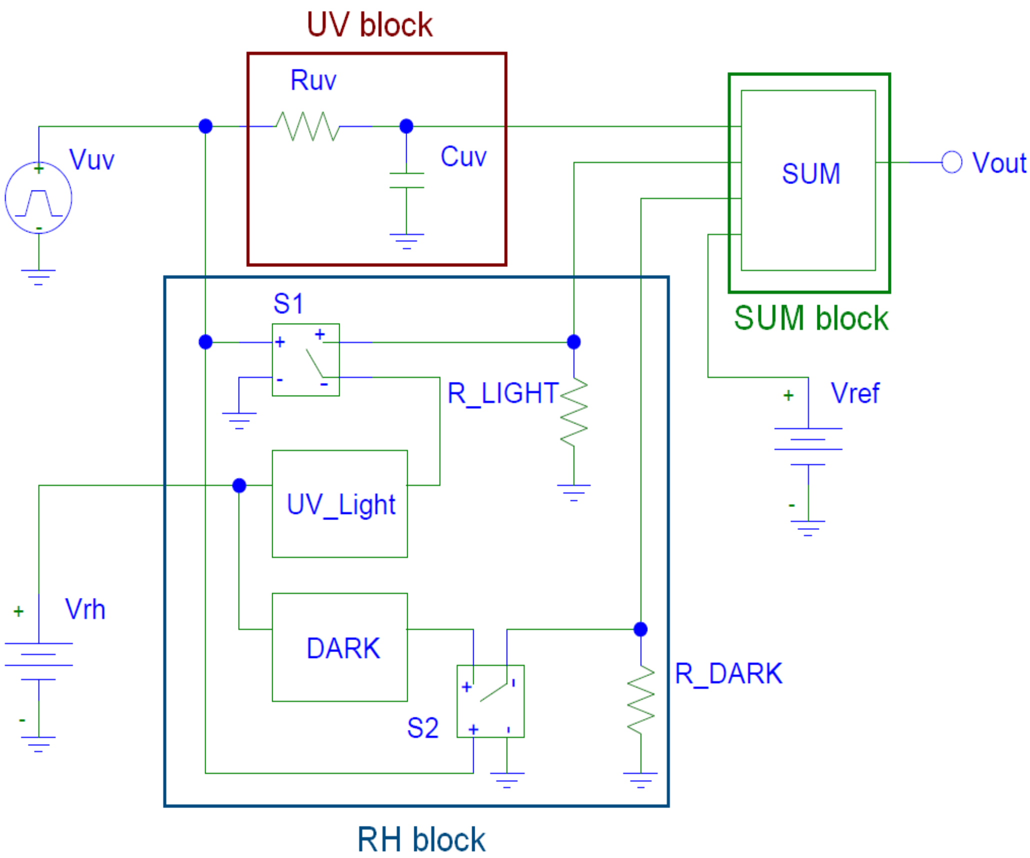

Fig. 4 Bloc diagram and schematic view of the UV photodetector.

The UV block simulated UV light transfer (*Vuv*), the RH block simulated relative humidity (RH), the SUM block evaluate response as a function of the UV irradiation and influence of RH. Voltage reference *Vref* is summed to SUM block.

3. Simulation results

On the base of equivalent circuit shown on fig. 4 was created subcircuit file SUBCKT and included in the library of PSpice program:

```
*Subcircuit
*                         UV
*                         |   RH
*                         |   |   REF
*                         |   |   |
.subckt UV_ photodetector 100 200 300 500; - Vout
UVblock
Ruv  100  101 {R_UV}
Cuv  101    0 {C_UV}
RHblock
E_UVlight 205 0 VALUE={(42m+{UV_S}*EXP(0.01*(V(200))))}
E_DARK 204 0 VALUE={(52m+{DARK_S}*(-((V(200))*(V(200)))+(V(200))))}
S1   222 205 100  0  VSWTH1
S2   204 233 100  0  VSWTH2
.MODEL VSWTH1 VSWITCH(RON=0.1 ROFF=1G VON=-0.2 VOFF=0)
.MODEL VSWTH2 VSWITCH(RON=1G ROFF=0.1 VON=-0.2 VOFF=0)
R_DARK  222 0 100k
R_LIGHT 233 0 100k
SUMblock
E_SUM 500 0 VALUE={((V(300))+(V(101))+(V(233))+(V(222)))}
.ends UV_photodetector
```

PSpice program:

```
*UV photodetector
.PARAM RH=53      ; relatice humidity 1->1%
.PARAM R_UV=1k    ; Resistence UVblock
.PARAM C_UV=30m   ; Capacitance UVblock
.PARAM DARK_S=1u  ; sensibility DARK
.PARAM UV_S=5m    ; Sensibility UV light
.PARAM UV=4.2V    ; UV irradiation
*                 ; (365nm~4.2eV) -> 1V=1eV
* Sources - UV Light, RH humudity, REF voltage
Vuv  1  0  PULSE(0V {-UV/3} 10s 1m 1m 75s 300s)
Vrh  2  0  DC {RH}   ; RH humidity
Vref 3  0  DC 1.25V  ; REF voltage
.lib E:\UVnanosensor.lib
x1 1 2 3 500 UV_photodetector
.DC Vrh 3 98 0.5V
.TRAN 0ns 300s
.PROBE v(500)
.END
```

Results of simulation is represented in Fig. 5. Dependence of the electrical resistance versus RH in the dark and under UV light is represented in Fig. 6.

4. Conclusions

Results of the present work is developed PSpice circuit model of UV photodetector. Was demonstrated that results are in good agreement with the experminetal data. Proposed model can be used in studying of an individual ZnO microwire-based UV photodetector in different circuit with PSpice models.

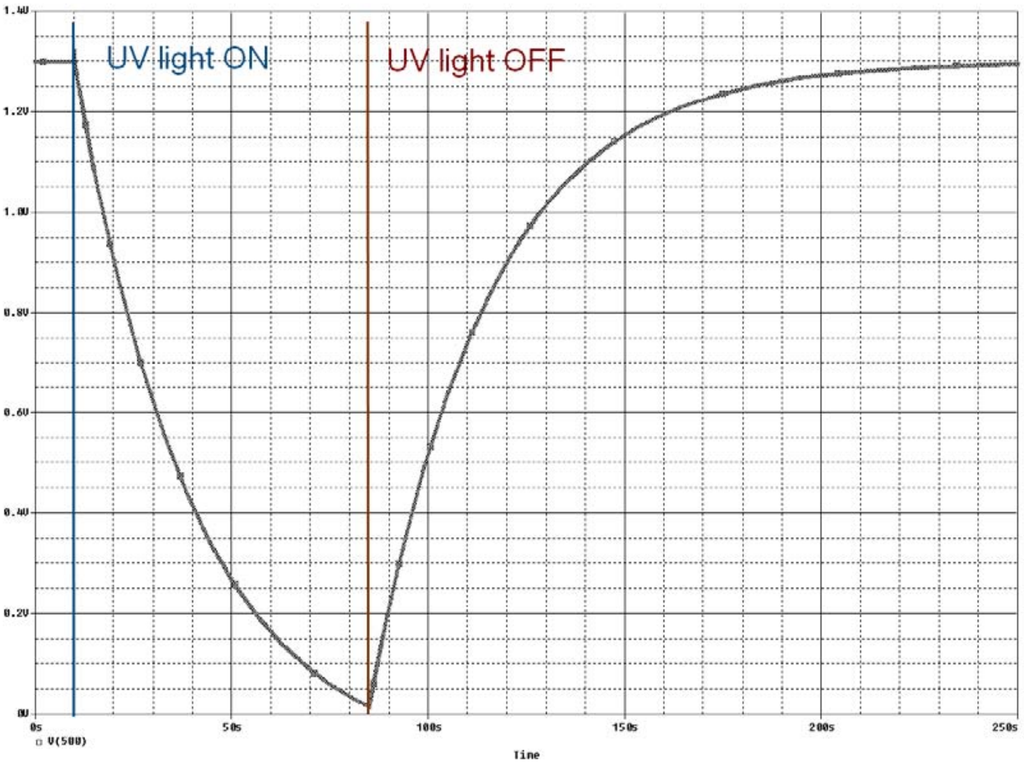

Fig. 5 Results of simulation UV photodetector PSpice model.

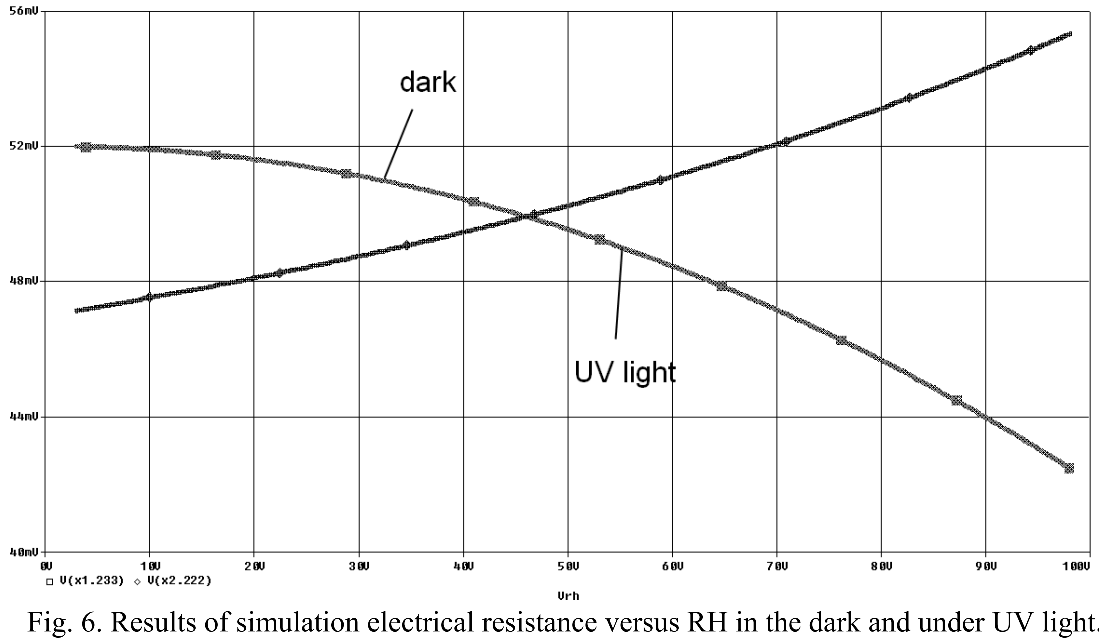

Fig. 6. Results of simulation electrical resistance versus RH in the dark and under UV light.

References:

1. O. Lupan, V.V. Ursaki, G. Chai, L. Chow, G.A. Emelchenko, I.M. Tiginyanu, A.N. Gruzintsev, A.N. Redkin *Selective hydrogen gas nanosensor using individual ZnO nanowire with fast response at room temperature* 2010.