DETECTAREA LUMINII UV PE BAZA REȚELELOR DE ZnO

UV LIGHT DETECTION BASED ON ZnO NETWORKS

Rajat NAGPAL, ORCID: 0009-0007-1266-1892*
Cristian LUPAN, ORCID: (0000-0003-2268-6181
Iulia SANDU, ORCID: 0000-0002-2906-7255
Adrian BÎRNAZ, ORCID: 0000-0002-2906-7255
Department of Microelectronics and Biomedical Engineering,
Center for Nanotechnology and Nanosensors,
Technical University of Moldova,
Chisinau, Republic of Moldova

CZU: 551.521.17:661.847.2

e-mail: rajat@doctorat.utm.md
e-mail: cristian.lupan@mib.utm.md
e-mail: iulia.sandu@mib.utm.md
e-mail: adrian.birnaz@mib.utm.md

ZnO network is considered as a good visible blind UV light detector. In this study we report room temperature UV detection analysis at three different wavelengths spread in UV-A and UV-B regions. Studied ZnO network is prepared by one of the most efficient methods: flame transport synthesis. ZnO network between two interdigitated electrodes were irradiated by UV radiation of three different wavelengths as 400nm, 370nm, and 280nm. The result analysis exhibits UV response of ~ 32, 28, and 11 at wavelength 370nm, 280nm, and 400nm, respectively. The UV response characteristics were measured and get analysed in detail with its sensing mechanism, correlating slow regeneration or decay time (~7.9s) to slow exchange of carrier's movement due to trapping of carriers by oxygen ions. The detailed sensing mechanism has been discussed.

Keywords: *UV light detection, ZnO, UV response characteristics.*

INTRODUCTION

ZnO is an excellent material for ultraviolet (UV) detection because of its wide band gap (E_g ~3.7eV at room temperature) and high exciton binding energy. UV photodetectors contribute to distinct fields like environmental monitoring, space exploration, optical communication and flame detection [1–3]. ZnO is one of the excellent photo detective material with ultrahigh electron mobility as high as 60 $cm^2V^{-1}s^{-1}$ and porous structure which helps in enhancing its photo efficiency [4]. ZnO material provides efficient path for electron transportation due to intrinsic point defects and native defects as an electron donor confirmed by lot of studies [4,5]. Due to slow diffusion or exchange of charge carriers trapped by oxygen in particular driving condition [6]. In this study, we demonstrate fabrication of ZnO network – based device. ZnO network bridging two interdigitated electrodes with separation gap between Au contacts as 0.3 mm. ZnO network exhibits excellent UV detection with high photoresponsivity due to lot of crucial factors as a) porous structure with large surface to volume ratio which provides hole trap states and prolongs photocarrier lifetime; b) reduced dimensionality of ZnO network which shortens the transit time [7,8].

UV detector based on ZnO network showed large UV response, when different intensity of UV light with different wavelength at room temperature irradiated on ZnO network surface. This study elucidates that current in ZnO network increases up to several orders upon UV light illumination, depends upon wavelength and intensity of UV light. This room temperature study exhibits about 10^6 orders of photoconductive gain for all three wavelength 400 nm, 370 nm and 280nm studied, UV response at three different wavelengths 400 nm, 370 nm, and 280 nm with response value ~28, 32, and 11 respectively. To demonstrate lucid UV response mechanism with good photo responsivity, excellent photoconductive gain and distinct sensing attributes for each wavelength studied. By comparing, we have determined that optimal wavelength for detection is 370 nm, with obtained response value of ~ 32 and response/recovery time of ~1.3/7.9 s. These results can be used for further adjustment of UV detectors based on ZnO networks. Overall, ZnO network – based device structure exhibits efficient response/recovery rate with high UV response value at biased voltage of 5 V.

MATERIALS AND METHODS

Synthesis of ZnO network

Zinc oxide network were synthesized by the method, developed by Mishra and group [9,10]. In this method, zinc powder (>99%) with extreme purity is heated at 900°C alongside a sacrificial polymer as polyvinyl butyral in ambient atmosphere. Zinc oxide can be burn during the burning process of polymer. After the complete burning of sacrificial polymer into carbon dioxide, due to high vapour pressure of Zn it evaporates and reacts with oxygen to form ZnO. Such a network morphology exhibits excellent performance [11,12].

UV measurement setup

Experimental setup used for UV measurement consists of Keithley 2450 source meter, UV LEDs, Peltier cooler for quick variation of temperature, etc. The whole setup is controlled by Coolterm software. An applied voltage used for making all measurement in different operating condition was set as 5 V.

Sensing properties of ZnO network

UV response (S) was determine using ratio of currents without UV exposure (I_{dark}) and during UV exposure (I_{UV}) [13].

$$S = \frac{I_{UV}}{I_{dark}} \quad (1)$$

This ZnO network-based sensor was tested at room temperature at three different wavelengths ranging at 400 nm, 370 nm, 280 nm and exhibits response value of ~28, 32, 11 respectively, as presented in Figure 1. This study is illuminated with different optical power as 4.1 µW, 5.6 µW, and 1.6 µW for wavelengths ranging at 400 nm, 370 nm, and 280 nm respectively.

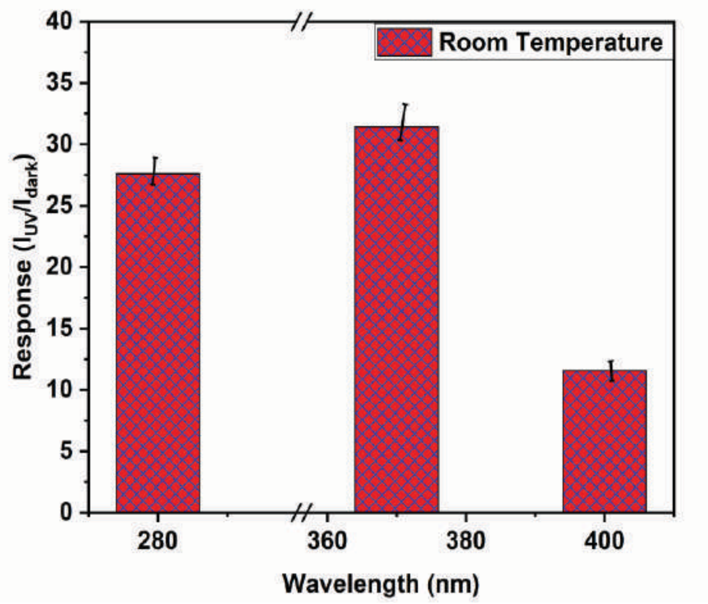

Fig. 1. Comparison of UV response for ZnO network-based sensor, investigated at room temperature (25°C) for different wavelengths.

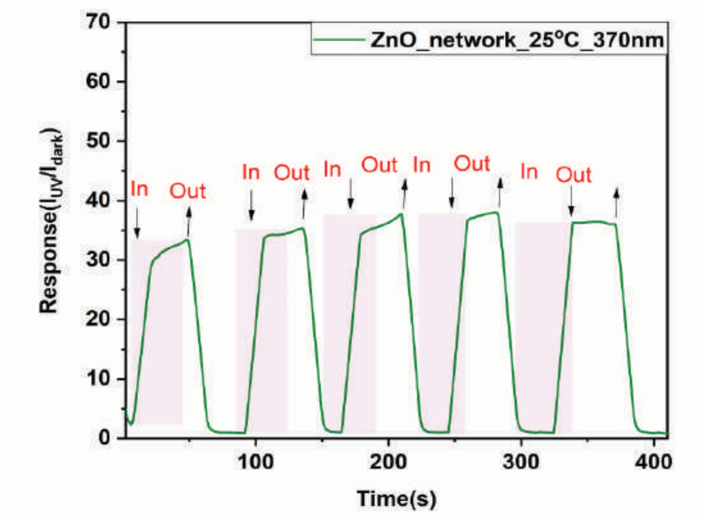

Fig. 2. Dynamic UV response for ZnO network -based sensor structure, investigated at room temperature (25°C) for 370 nm wavelength.

In Figure 2 is presented dynamic response for ZnO network -based sensor, at room temperature, observing a maximum response of ~35. To check repeatability, we applied multiple UV light multiple times, obtaining a similar response. From dynamic response we determined response and recovery time, which are summarized in Figure 3. Response time represents the time it takes for response value to increase from 10% to 90% of the maximum value [13]. Recovery time represent time it takes for the sample to reach 10% from 90% of the maximum value.

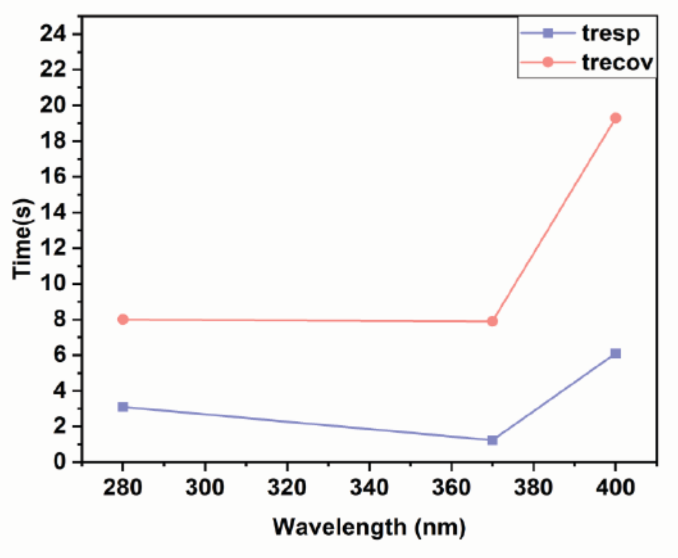

Fig. 3. Response/recovery time at different wavelengths at room temperature.

Overall, UV sensing measurement performed at room temperature shows excellent sensing performance. This studied ZnO network exhibits most efficient UV sensing performance at 370nm with UV response value of ~32 and response/recovery time of ~1.3/7.9 seconds. This recorded response time at 370 nm is about 4-5 times less than as of at 400 nm and response time recorded at 370 nm is about 2-3 times less than as of at 280 nm. Similarly, recovery time recorded at 370 nm is about three times less than as of at 400 nm and about same as of at 280 nm as shown in Figure 3.

This study elucidates dynamic UV response of ZnO network at room temperature exhibits excellent UV sensing performance at 370 nm. This is ascribed as due to the intrinsic property of wurtzite crystal structure of ZnO as 370 nm wavelength is in correspondence to its band gap energy at which effective recombination electron-hole pair occurs. In particular driving conditions, response time can be seen as quick as compared to decay time which shows slow regeneration due to charge carrier trapping by oxygen adsorption in diffusion process [6].

CONCLUSIONS

In summary ZnO network was integrated into an UV sensing device structure, working at room temperature with 5V bias voltage. ZnO UV detection responds efficiently as fast, highly sensitive and selective UV sensor at 370nm wavelength, with a response value of ~32. The effective conductance of ZnO under UV illumination is due to electron hole pair generation.

By applying UV light multiple times, we obtained similar response value, meaning that ZnO networks UV sensing results are repeatable. Response recovery time as ~1.3/7.9 seconds was shortest for 370 nm, which is best UV sensing performance among all the three studied wavelengths.

These results can be used for further optimizing UV detectors based on ZnO networks, by adjusting optimal wavelength, in order to achieve maximum performance.

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