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# The electrical properties of ZnO MSM Photodetector with Pt Contact Electrodes on PPC Plastic

**Nidhal. N. Jandow[a], Kamarul Azizi Ibrahim [a], Haslan Abu Hassan[a], Sabah M. Thahab [a], and Osama S Hamad [b]**

[(a)]Nano-Optoelectronics Research and Technology Laboratory
School of Physics and [(b)] School of Electrical and Electronic Engineering
Universiti Sains Malaysia (USM),
11800 Minden, Penang, MALAYSIA.
Corresponding authors email: sunmoonloveme@yahoo.com , kamarul@usm.my, and haslan@usm.my, hammad762008@yahoo.com

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## Abstract

ZnO thin film was deposited on Poly propylene carbonate (PPC) plastic substrate by direct current (DC) sputtering. The measurements of the absorption spectrum and the photoluminescence of the film were carried out. ZnO Metal-Semiconductor–Metal (MSM) photodetector with platinum (Pt) contact electrodes was then fabricated. The structural and electrical properties of the detector were investigated using the current–voltage (I–V) measurements.

**Keywords:** ZnO; MSM Photodetector; Schottky Diode; DC Sputtering
**PACS:** 68.55.-a; 78.20.-e; 73.40.Sx; 85.30.-z

## 1. INTRODUCTION

Detection of ultraviolet (UV) radiation is becoming important in a number of areas, such as flame detection, water purification, UV astronomy, and UV radiation dosimetry [1]. Recently, wide-bandgap materials are under intensive studies to improve the responsivity and stability of UV photodetectors [2]. Among them is zinc oxide (ZnO) which is of great interest due to its strong UV photoresponse.

ZnO Schottky diodes and metal–semiconductor–metal (MSM) photodiodes detecting in the UV region have been investigated [3]. To produce high-performance MSM UV photodiodes, it is important to achieve a large Schottky barrier height at the metal–semiconductor interface that leads to small leakage current and high breakdown voltage which could result in improving responsivity and photocurrent to dark current contrast ratio. To achieve a large Schottky barrier height on ZnO, one can choose metals with high-work functions [4]. However, many of the high-work function metals are not stable at high temperatures. Platinum (Pt) is an interesting metal that has recently been used as a stable Schottky contact because it has the highest metal work function which equal to 5.65eV eV. Several investigations on deposition ZnO Schottky diodes with Pt contact electrodes have been reported using silicon, glass or other substrates[5] . However, there is no study on the characterization of ZnO MSM photodetectors with Pt contacts or other metals using plastic substrates, such as poly propylene carbonate (PPC). In this work, we report the deposition of ZnO thin film on the PPC plastic and the fabrication of ZnO-based MSM photodetector with Pt electrodes and the I-V characteristic of the built photodetector.

## 2. Experimental work

ZnO thin film was deposited on plastic sheet of PPC of thickness 0.1 mm by DC sputtering. The target material used is ZnO disk with purity of 99.99%. The plastic substrate was cleaned by immersing in the active cleaning liquid (DECON90) for 5 minutes, then rinsed with distilled water, and dried by $N_2$ gas. The thin film thickness was measured by using surface optical system Filmetric F20-VIS. The transmission spectrum of the sample was measured by using a Hitachi U-2000 Double-beam spectrophotometer. The photoluminescence spectrum (PL) was recorded by using photoluminescence spectroscopy system Model: Jobin Yvon HR 800 UV. The line of He-Cd laser of 320 nm having a power of 1 mW is used to excite the sample. The morphology of the film surface was imaged by scanning electron microscopy (SEM) and atomic force microscopy (AFM). ZnO MSM photodetector was fabricated by sputtering the Pt with a thickness of about 140 nm on the thin film by using a metal MSM mask.

## 3. RESULTS AND DISCUSSION

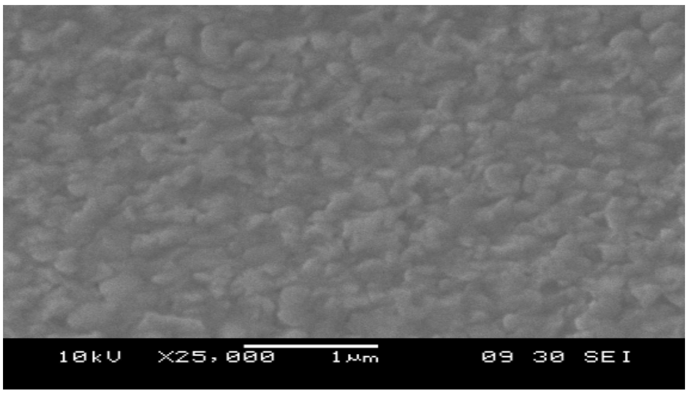


Fig. 1. SEM image of ZnO film on PPC substrate

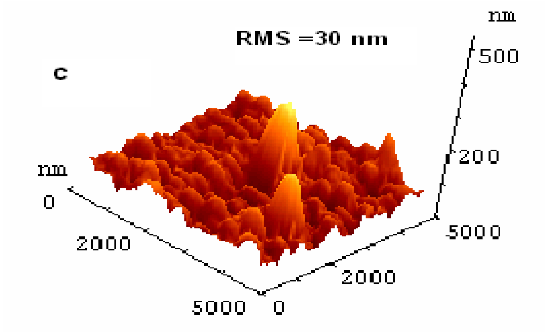


Fig. 2. AFM image of ZnO film on PPC substrate

The thickness of the prepared film was found to be about 1µm. The morphology of the film is shown in Figs. 1 and 2 respectively. Fig. 1 shows the top surface SEM image of ZnO film grown on the plastic sheet; while Fig 2 shows the structure of the film which consists of some columnar structure grains of height about 200nm; this nanostructure of the film surface may be useful in the absorption of the UV light when this material is used as a UV detector.

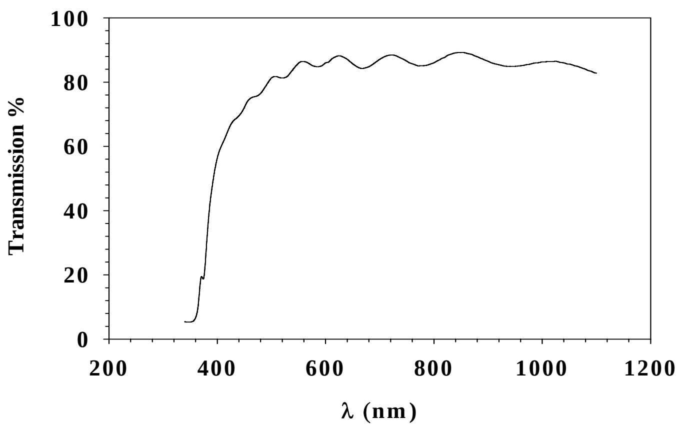


Fig. 3 Transmission spectrum of ZnO thin film on PPC substrate

Figure 3 shows the optical transmission spectrum of ZnO thin film in the range of 300-1100 nm. The transmission in the visible region was found to be higher than 85% with a sharp UV cut-off wavelength value approximately at 380 nm and has good absorption to UV light which indicates that the film can be used as transparent windows for UV light or as electrodes in a MSM photodiode [5].

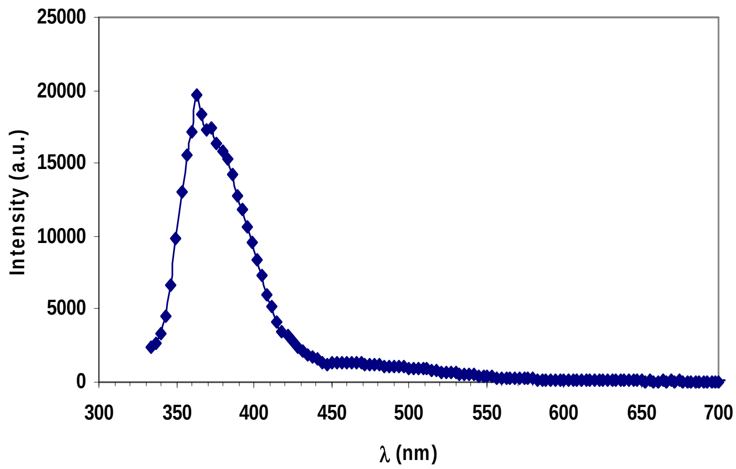


Fig. 4PL spectrum of ZnO thin film on PPC

Figure 4 displays the PL spectrum of the ZnO thin film with a high UV emission peak (380 nm) and a low and broad blue–green emission peak (490 nm). The high UV to visible emission ratio indicates a good crystal quality of the film i.e., a low density of surface defects. The emission at 380 nm corresponds to the bandgap of ZnO material according to L. Dong and et al [6], this UV emission is assigned to the recombination of bound excitons of ZnO. The blue–green emission mechanism in ZnO has been extensively investigated. Single ionized oxygen vacancy results in green emission of ZnO material because of recombination of a photogenerated hole with a single ionized electron in the valence band [7].

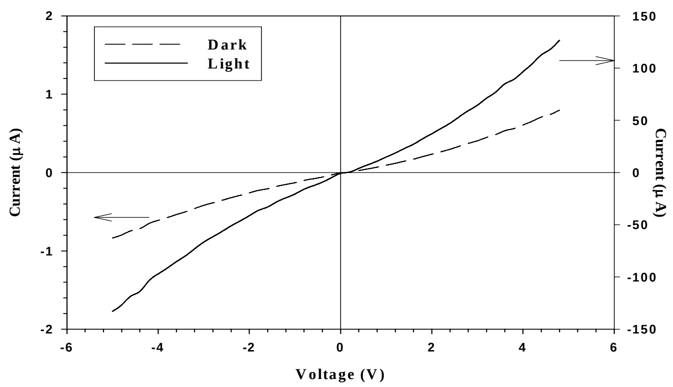


Fig.5: I–V characteristics of the fabricated ZnO MSM photodetector with Pt electrodes on PPC substrate, measured in (dark current) and (photocurrent).

Figure 5 shows the I-V characteristics of the fabrication ZnO MSM UV detector with Pt electrodes on PPC plastic, which was measured in the dark (dark current) and under illumination (photocurrent). The photocurrent measured by using Xe lamp with power of about 26.8 μW at the incident wavelength 385 nm. It was found that the dark current and photocurrent of ZnO MSM photodetector were (0.7957, 126.5163 µA), respectively. In other words, the researchers have obtained the photocurrent to dark current contrast ratio of 159 which illustrated that the ZnO photodetector showed a good photoconductivity.

## Conclusion

In conclusion, ZnO thin films were deposited on PPC plastic Substrates by DC-Sputtering. The Pt/ZnO/Pt MSM UV photodetector was then fabricated. The transmission spectrum of the film showed that the film is transparent in the visible region, and it absorbs in the UV region.

It was found that the dark current and photocurrent of ZnO MSM photodetector were (0.7957, 126.5163 µA), respectively and the photocurrent to dark current contrast ratio was found equal to159. These results showed that the fabrication of ZnO MSM UV photodetector on plastic substrates at room temperature is possible by using DC-sputtering technique.

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## REFERENCES

1. L Ying, F Shiwei, Y Ji, Z Yuezong, X Xuesong, and et al, *optoelectronic China* **1(3–4),** 309–312 (2008)**.**
2. N Biyikli, O Aytur, I Kimukin, T Tut and E Ozbay, *Appl. Phys. Lett.* **81**, 3272–3274 (2002) *Thin Solid Films* **516,** 5571–55 76(2008).
3. J S Young, W L Ji, H T Fang, J S Chang, K Y Su and L X Du, *Acta Materialia* **55**, 329–333 (2007)
4. J S Young, W L Ji, J S Chang, P Y Chen and M S Peng, *Semicond. Sci. Technol.* **23**, 085016 (2008).
5. X.G. Zheng, Q.Sh. Li, J.P. Zhao, D. Chen, and et al. Applied Surface Science **253,** 2264 – 2267, (2006).
6. L. Dong, Y. C. Liu, Y. H. Tong, and Z. Y. Xiao, "Preparation of ZnO colloids by aggregation of nanocrystal subunits," *J. Colloid Interface Sci.*, vol. **283**, pp. 380–384, (2005).
7. Linda Y. L. Wu, A. I. Y. Tok, F. Y. C. Boey, X. T. Zeng, and X. H. Zhang, IEEE TRANSACTIONS ON NANOTECHNOLOGY, VOL. **6**, NO. 5, SEPTEMBE 497 (2007).