International Journal of Luminescence and applications
Vol7 (1) April, 2017, **ISSN 2277 – 6362**

PHOTOCONDUCTIVE ULTRAVIOLET SENSOR BASED ON ZnO NANOPARTICLES DECORATED WITH CARBON DOTS

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Introduction:

Use of nanostructures materials for UV photoconductive sensor applications has shown many advantages over bulk structures namely high gain, high sensitivity, reduced dimensionality, low power consumption and higher atom economy. This enhanced photosensitivity of nanomaterials can be attributed to the enhanced surface to volume ratio, surface defects, lower charge carrier recombination and prolonged carrier lifetime [1]. Current research has mainly focused on high mobility nanostructures needed for good device performance. Review of the current status of the UV photodetective sensors suggests that 1D ZnO Nanowire (NW) structures are very promising for UV detection due to their large surface area, high mobility and promising photochemistry. However the defects produced during synthesis of these ZnO NW cause a decrease in photoconductivity (PC) due to low photogenerated carrier lifetime and less effective UV absorption properties. Presently, we have synthesized ZnO NW by a simple and cost effective microwave assisted wet chemical method followed by post deposition modifications and compared their performances as a photoconductive sensor. We found that there are several factors which influenced the UV sensor performance like annealing, surface treatment and morphology of nanoparticles . Further, the ZnO NW were decorated with carbon nanoparticles for improving the mobility of the photoelectrons. As carbon is an important versatile material due to its biocompatibility, high electrical conductivity and large surface area [2].

Experimental: Pristine ZnO nanoparticles were grown on pre-cleaned FTO substrates with a ZnO seed layer, through microwave assisted hydrothermal method. A thin layer of PVA was coated for surface passivation. For studying the effect of carbon decoration the as prepared substrates were immersed in a 50 mL 0.5 M glucose aqueous solution for 10 h. Then they were subjected to pulsed microwave irradiation for 10 minutes with a 5s on/ off cycle. A uniform thin layer of glucose molecules adsorbed on the surface of ZnO, which forms a carbon shell around ZnO nanoparticles after microwaving [3]. XRD and SEM studies were performed at IUC-DAE Indore(M.P.) India, using models Rigaku RU: H2R horizontal Rota flex and JEOL- JSM 5600 respectively.

Effect of surface passivation: Figure 1 and 2 show the SEM and XRD of PVA passivated ZnO NW. An increase in the sensor responsivity involved the surface passivation of ZnO NW by a thin layer of PVA. Responsivity was calculated by the following formula:

$$R = (I_{ph} – I_{dark})/ P_{op} \quad (1)$$

where , R is responsivity; I_{ph} is photo current; I_{dark} is dark current; P_{op} is optical power supplied by UV source.

Carbon decorated ZnO NW show maximum gain, on/off ratio, mobility and responsivity. It has been reported that PVA surface passivation reduces the number of defects [4]. This eventually increases the ratio of photocurrent over the dark current compared to the uncoated ZnO NW. The surface passivation decreases the number of holes in the deep level, which helps the UV excited electrons to recombine with the holes in the valence band without being trapped in the deep- level defects of ZnO. The highest PC was observed for an optimized concentration of PVA.

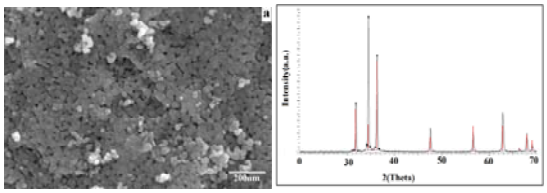

Figure1: SEM /XRD of PVA capped ZnO NWs

Effect of annealing: The as prepared ZnO NW was annealed at 300-700^{0}C to study the effect of thermal

treatment on the PC of the samples. Annealing reduces the defect concentrations in the NW, which eventually increases PC [5]. *Figure3 and 4* shows the PC rise and decay curves for un- passivated/ passivated/ annealed/carbon decorated ZnO NW. Various parameters obtained through PC studies are compiled in Table 1.

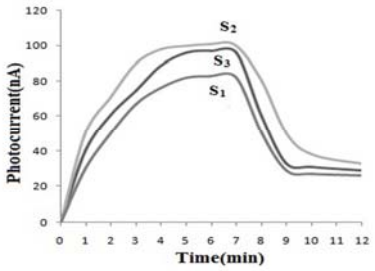

Figure 3: Rise and Decay of photocurrent with time for ZnONPs surface passivation with various concentrations of PVA as S_1(.5M),S_2(.75M), and S_3(1M).

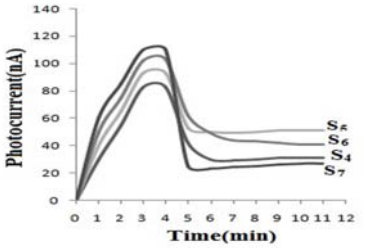

Figure 4: Rise and decay curve of photocurrent with time with effect of annealing in PVA capped ZnONWs; S_4(300^{0}C),S_5(500 ^{0}C), S_6(700^{0}C), and S_7(Carbon decorated Annealed ZnONWs).

Effect of carbon decoration: The PC studies indicate that maximum saturation current was attained by ZnO NW decorated with carbon with the highest on/off ratio (Table 1); which can be attributed to the faster transfer of electrons from carbon to ZnO, as the work function of carbon is 4.5–4.6 eV which is close to electron affinity of ZnO. This fact indicates that carbon is promising as a cathode electrode material because it improves the efficiency of electron collection [6]. Further the 1D ZnO structure provides direct electron pathways for transferring electrons immediately from carbon to electrode substrate.

Conclusions: Present study focuses on enhancing the photo-sensitivity and photo-response of ZnO NW based photoconductive optical sensors. The photosensitivity was improved by surface passivation by PVA, and annealing. Carbon decorated ZnO NW show maximum gain, on/off ratio and mobility. As the future scope of this study, we propose to attach the UV sensors to a wireless detection system through optical waveguides for making efficient fire alarms, which can send signals to a base station in case of emergency.

Table.1: Comparison of Parameters calculated from PC studies

S.No..	Samples	Gain X(10^6)	On/off ratio	Mobility $cm^2.V^{-1}.S^{-1}$	Responsiity R
1	S_1	2.45	0.48	40.50	0.23
2	S_2	3.16	0.50	48.83	0.30
3	S_3	3.04	0.41	39.53	0.29
4	S_4	2.45	0.36	42.21	0.23
5	S_5	2.80	0.43	51.02	0.27
6	S_6	3.29	0.48	55.71	0.31
7	S_7	3.35	0.54	62.43	0.34

Acknowledgement: First author gratefully acknowledges CCOST, Raipur (C.G.) India for partially funding this research through project# 1219/CCOST/MRP/2014.

References:

[1]C. Soci, A. Zhang, X. Y. Bao, H. Kim, Y. Lo and D. Wang,"Nanowire Photodetectors", *Journal of Nanoscience and Nanotechnology*, **10**, .1430- 1449, 2010.

[2] S. Wu, H. Ju, Y. Liu, "Conductive Mesocellular Silica–Carbon Nanocomposite Foams for Immobilization, Direct Electrochemistry, and Biosensing of Proteins", *Adv. Funct. Mater.***17**, 585- 592, 2007.

[3] J. Liu , C. Guo , C. M. Li , Y. Li , Q. Chi , X. Huang , L. Liao , T. Yu, "Carbon-decorated ZnOnanowire array: A novel platform for direct electrochemistry of enzymes and biosensing applications" *Electrochemistry Communications,* **11**,202-205, 2009.

[4] L. Qin, C. Shing, S. Sawyer, and P. S. Dutta, "Enhanced ultraviolet sensitivity of zinc oxide nanoparticle photoconductors by surface passivation" *Optical Materials*, **33**, 359- 362, 2011.

[5] Lee, J.; et al, "Improvement of optical properties of post-annealed ZnO nanorods". *Physica E: Low-dimensional Systems and Nanostructures*, **42**, 2143- 2151, 2010.

[6] Z. Yin, S. Wu, X. Zhou, X. Huang, Q. Zhang, F. Boey and H. Zhang, 'Electrochemical deposition of ZnO nanorods on transparent reduced graphene oxide electrodes for hybrid soalr cell' *Small*, **6**, 307- 314, 2010.