

Performance of ZnO NWs and Core-Shell Structures as Gas and UV Sensors

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We compare the performance of hydrothermally grown ZnO nanorods (NRs) as gas sensors and ultraviolet (UV) sensors with ZnMgO/ZnO core-shell structures. ZnO nanowires (NWs)/ NRs have been implemented as hydrogen[1], humidity[2], glucose[3] and UV sensors[4], among others. Bai et al. fabricated ZnO NWs based UV sensor and reported faster response by increasing the density of NWs [5]. A core-shell structure allows higher density of NWs per unit area which should result in faster responsive sensors.

The low temperature hydrothermal growth ZnO NRs on flexible plastic and p-Si substrates was performed in two steps. Initially, 90 mg of zinc acetate and 120 mg of potassium hydroxide were dissolved in 50 ml of methanol and then constantly stirred for 5 min at 60°C. Using this zinc acetate solution as a seed layer, the samples were spin coated. The epilayer was grown by immersing the samples in an 0.1 M aqueous Zn(NO₃)₂ solution and 0.1 M of HMTA at 90°C in a laboratory oven for 1 hour. Finally, NR growth was accomplished in a water bath at 70°C using an equi-aqueous solution of 25 mM Zn(NO₃)₂ and HMTA for 3-7 hours [6].

Scanning electron microscope (SEM) image of the nanorods grown on flexible substrates (Figure 1) shows vertical alignment with a diameter ranging from 200nm – 400nm and a length variation in the range from 1µm to 2 µm, depending upon growth time and temperature. The X-Ray Diffraction (XRD) pattern of the ZnO nanorods exhibits a predominant peak corresponding to ZnO orientation along 0002 direction with the extracted c-lattice constant of 5.19Å. The XRD spectra showed very low intensity along 100, 101, 102, 110, 103 directions suggesting only minor disorientations.

Figure 2 shows the sensing performance of ZnO NR devices in acetone and methanol environments. The ZnO gas sensor consisted of two copper contacts deposited on top of the ZnO NRs with an effective contact area of 1cm². The gas sensor was biased with a 5V DC power supply in a simple voltage divider arrangement with a 100 kΩ resistance. The voltage drop across the 100 kΩ resistance was observed using an oscilloscope. In order to investigate the response of the device under methanol, the sensor was inserted in a Florence flask, sealed with rubber stoppers. After the sensor being exposed for 20 seconds with methanol the voltage across the resistor rose from 0.9 mV to 5.2 mV, indicating a drop in the initial resistance of the sensor. Once the device was taken to air, the resistance of the device reached its initial value. The cycle was repeated a few times in the same manner and a lower voltage drop was observed in the subsequent cycles.

Figure 3 shows the UV response of ZnO nanorods grown on p-Si substrates with indium as metal contact. The device showed an increase in the output current when exposed to a UV lamp of 355nm wavelength for 500 sec under 3V reverse bias.

A core-shell NW structure was synthesized to enhance the performance of the gas sensors and UV sensors. Figure 4 shows the SEM image of secondary NWs grown using hydrothermal synthesis at 90°C

seeded from the top face of NRs. Characterization of the performance of this core-shell ZnMgO/ZnO NW structure and comparison with the 1D oriented ZnO NWs will be presented at the conference.

References

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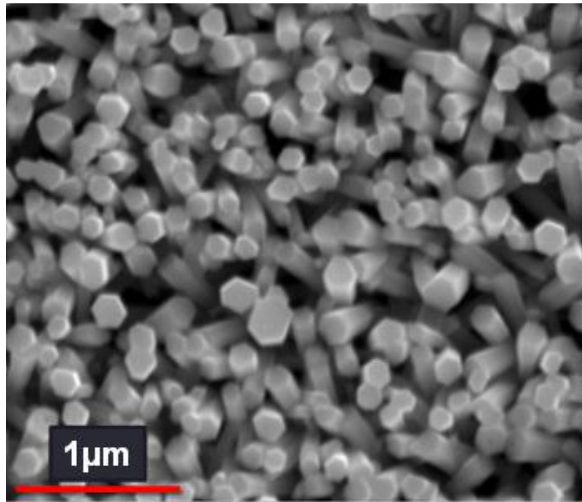


Figure 1 – SEM of ZnO nanorods grown using hydrothermal synthesis without secondary nucleation and hexagonal shape.

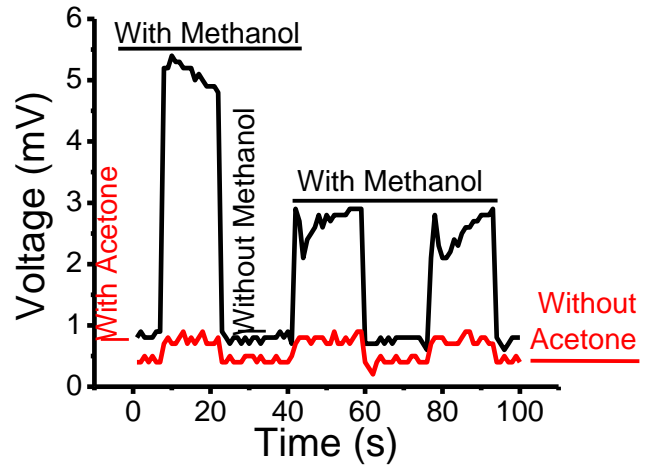


Figure 2 – Output voltage as a function of time under methanol and acetone environment.

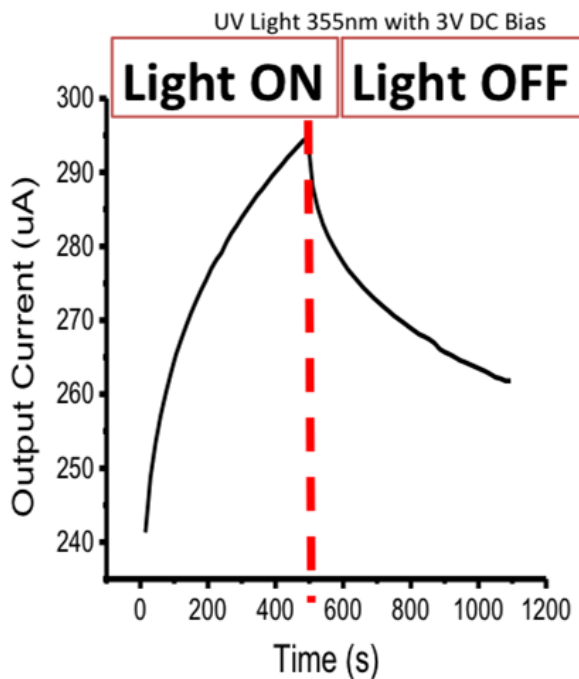


Figure 3 – Output current (μA) as a function of time of ZnO nanorods exposed to UV light with 3V DC bias.



Figure 4 – SEM of ZnO nanowires core-shell structure seeded on top of ZnO NRs synthesized using hydrothermal method.