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Research Article

FABRICATION, CHARACTERIZE AND OPTICAL PROPERTIES OF ZINC OXIDE NANOWIRE ON TO A SILICON SUBSTRATE WITHOUT USING CATALYST

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ABSTRACT
Pure zinc oxide nanowire, with proper vertical shape, can be grown on to a silicon substrate by using vapor-solid (V-S) process. These nanostructures have been produced without assistance of foreign element catalytic agents. Although our method eliminated auxiliary interface layer and used environmental pressure instead of using furnace pressure. Scanning electron microscopy (SEM) image of zinc oxide nanowire showed a proper environmental controlling in condition of supersaturated zinc oxide vapor which resultin a vertical and uniform of nano-elements. The EDX evaluation showed the combination of elements of pureness of semiconductor zinc oxide and single crystal hexagonal structure was approved. Photoluminescence measurement showed an X-ray diffraction with a peak on 383 nm which is equal to zinc oxide forbidden diffraction band. Furthermore a visible green light on 494 nm confirmed the oxygen ion cavity in a grown nanostructural crystal network.

Keywords: *Zinc Oxide, Nanostructure, Nanowire, Photoluminescence*

INTRODUCTION
Nowadays one-dimensional vertically growing nano-semiconductors are considered to be ideal choice in various applications such as sensors (Johnson, 2001), light emitting diode (Nickel and Terukov, 2005), laser (Wang, 2004), photo detectors and field effect radiation transistors. Different kinds of physical and chemical approach have been reported in order to fabricating zinc oxide nanostructure with various properties and shapes. The vapor-solid (V-S) mechanism is one of the most common method for producing nanostructure which is investigated by many researchers (Wang, 2004; Karamdel and Hadi, 2012; Makino and Chia, 2000; Zakirov, 2011; Goswami, 2011; Zheng, 2002). In this approach zinc oxide powders were vaporized and the resulting vapor was immersed on to substrate with a proper distance. In some method catalyst were used in order to create some island for starting growth process of nanostructures (Fan and Lian, 2005). Some unintentional impureness could be made by using catalyst. Therefore making nanostructures without assistance of catalyst were result in vertical and pure nanowires. However many factors such as inherent polarity of the substrate surface, incomplete distribution of crystal and the speed of nanostructures growth can effect on nanostructure's production (Roy and Djuri, 2004; Mahmoud, 2011).
In this paper, we report a new method for growing pure zinc oxide nanowires without using any catalysts on to a silicon substrate.in addition, initial steps of growing were illustrated by electronic microscope for highlighting the growing procedure of nanowires.

Experimental
A furnace with temperature controlling option (up to 1100º C) was used for growing zinc oxide nanowires with physical vapor deposition (PVD) method. As illustrated in figure 1, thefurnace consist of two quarts tube. The internal tube has a diameter of 25 mm and the outer one's diameter is 50 mm. the length of external tube is exactly equal to the length of furnace and the internal tube was placed in a way that edge of outer tube became depth. The zinc oxide powders were placed in a 24 cm far away of the internal tube's edge which was empirically identified to be the hottest point of furnace. After carrying out some experiments about location of substrate, the best place was found with a distance of 12 till 17 cm from

zinc oxide powders. Nanowires were grown in smaller tube which result in reducing pollution and limited the passing air. Zinc oxide was mixed with graphite in order to reducing the melting temperature. The ratio of this mixing process is 1:1.

After washing tubes with sulfur and HF acid were placed in ultrasonic environment. The amount of 0.3 gram of mixed powders were put into the internal tube with a distance of 15 cm. Temperature of furnace was set to 50ºC/Min range for reaching the maximum of 900ºC meanwhile as the temperature reached to 500ºC a nitrogen gas was used in order to make uniform flow. The nitrogen gas acts as a carrying gas. The above procedure continued for 85 minutes, then the temperature of samples were reduced to the temperature of surrounding area.An electronic microscope (Hitachi S4160) was used for showing the schematic of grown samples (figure 2 till 4).

RESULTS AND DISCUSSION

Results

Nanowires had a proper density on the surface as illustrated in figure 2.A. In figure 2.B, the uniformity and vertical shape of grown nanowire was shown from a different angle. This desirable growth could be the result of proper supersaturated zinc oxide powders which were mixed by graphite and uniformity of passing air (Karamdel, 2010). A nanowire illustrated in figure 2.C. In this figure the hexagonal crystal structure of zinc oxide is clear. Another test has been done in case of more understanding about growing process. In this test the procedure of growing was repeated as before except that the temperature of furnace was reduced quickly before starting of growing.

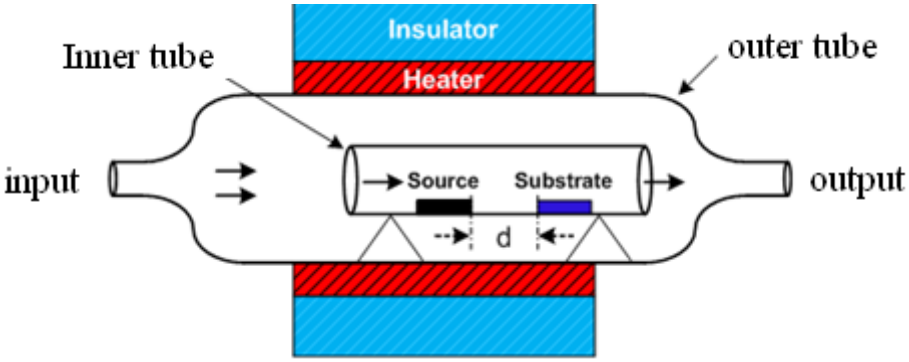
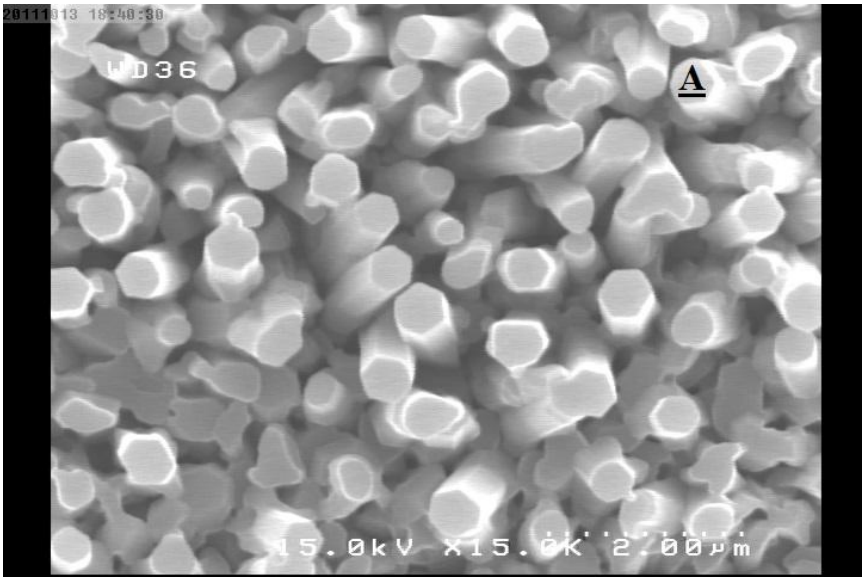
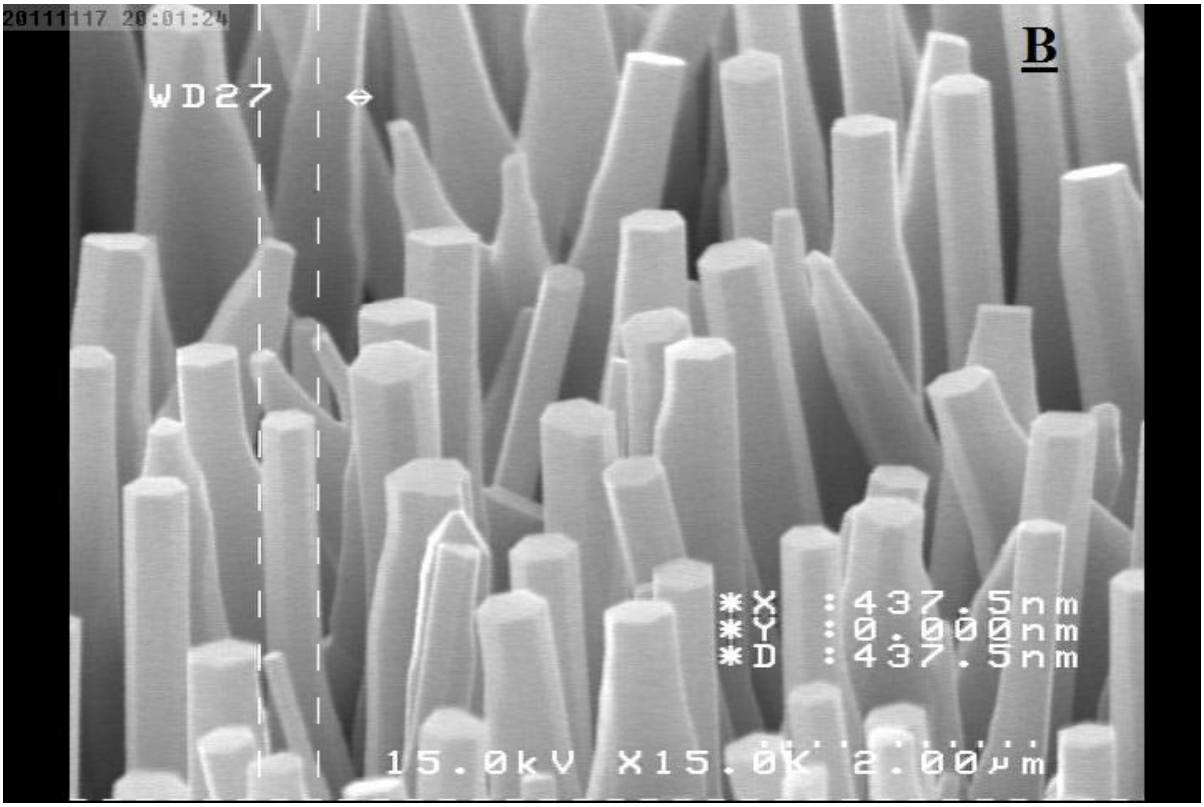


Figure 1: Fabricating nanostructure base on PVD method





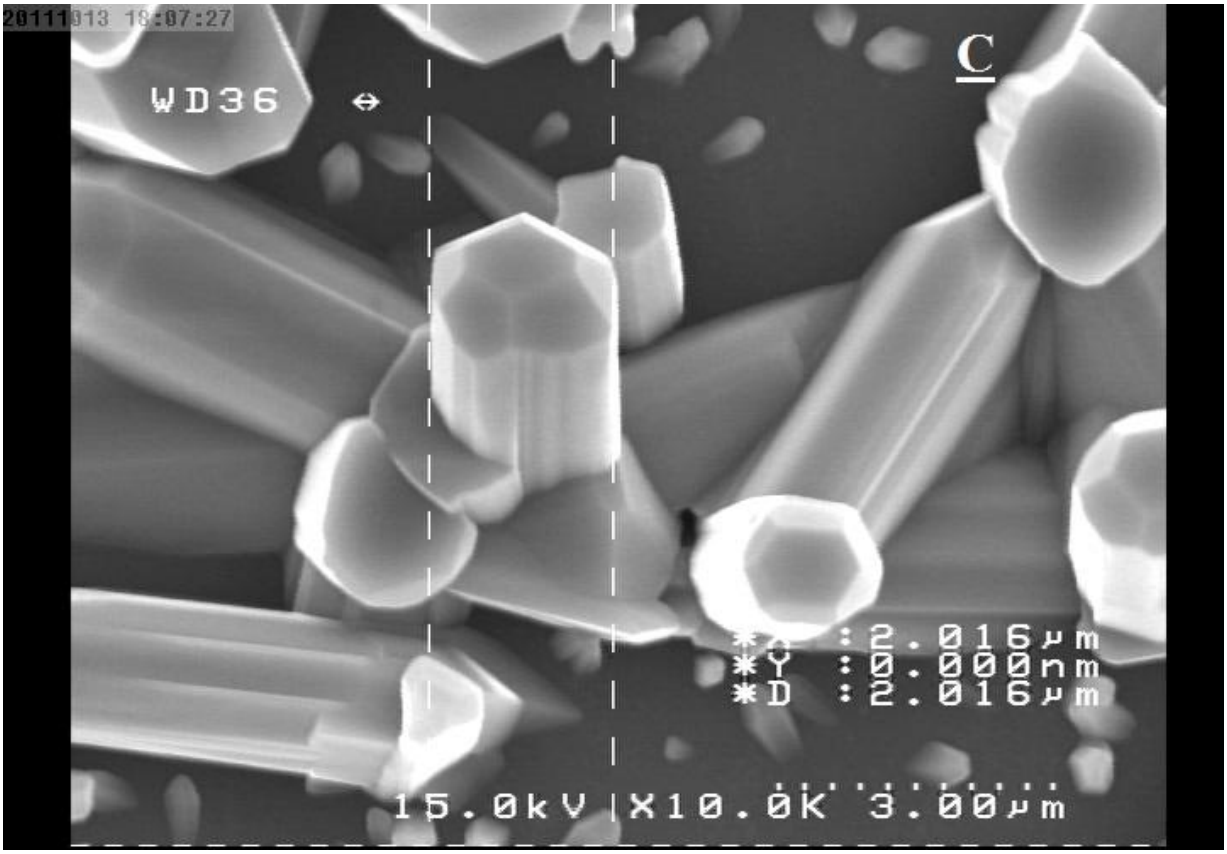


Figure 2: Scanning electron microscopy image of grown samples

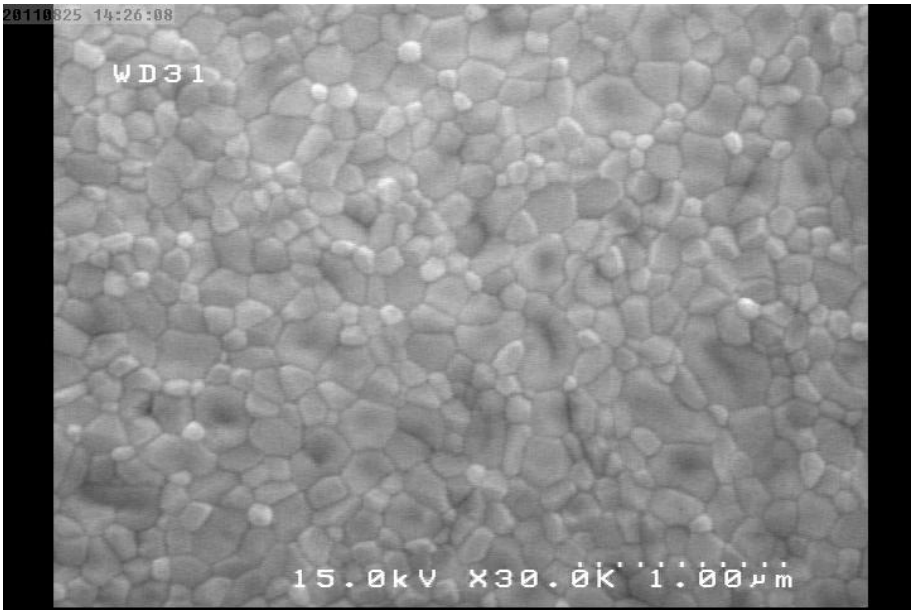


Figure 3: Scanning electron microscopy image of samples that were going to fabricate

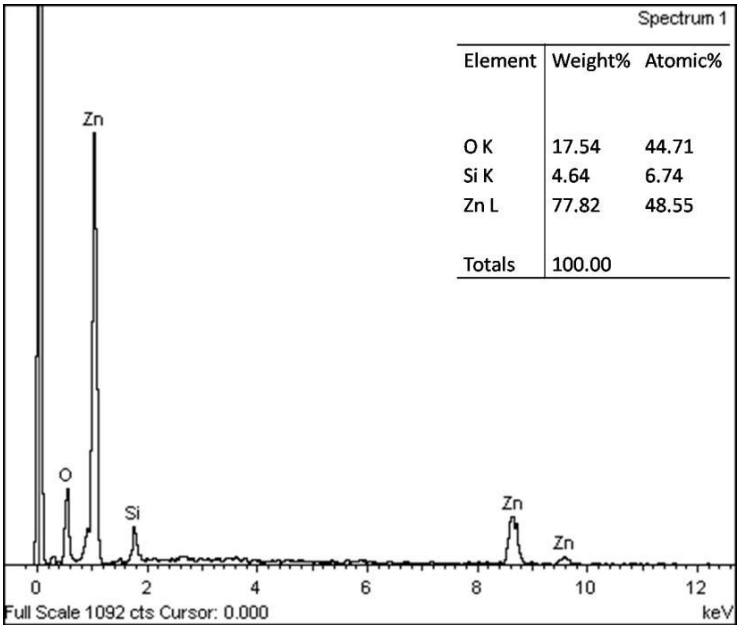


Figure 4: EDX spectrum which show the equal amount of oxygen and zinc oxide

The result of this test showed in figure 3. As illustrated in figure 3, it is obvious that the nanostructure was going to start growing and it is also expected that the growing process happen on ridge places (Hadi and Hajghassem, 2013). The EDXmeasurement was used in case of determining the elements which showed in figure 4. The amount of oxygen (44.71%) is approximately equal to the amount of zinc oxide (48.55%). The existence of a 6.74% silicon is because of substrate. The difference between of cavity of them in crystal network (Reynolds, 2001). The less difference between oxygen and zinc oxide the better crystal (Wang, 2007). Photoluminescence analysis has been done by Carry Eclipse system and the result is shown in figure 5. As it is shown in figure 5 there are two peaks, the first one is on 383.07 nm which is equal to zinc oxide forbidden diffraction band and the second one is visible green light (493.93 nm) that reveal the oxygen ion cavity in a grown nanostructural crystal network (Aravinda, 2012).

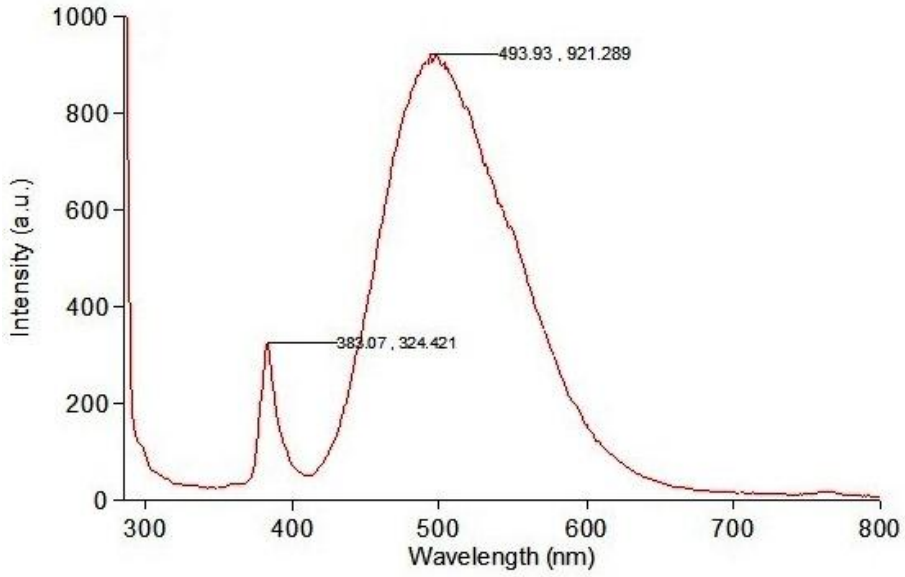


Figure 5: PL analysis result from fabricated nanostructures without using catalyst

Conclusion

Uniform zinc oxide nanowires have been fabricated based on the PVD method without using catalyst. The growing process have been done by a furnace consisting of two tubes with temperature of 1100º C. the EDS analysis show that zinc oxide nanowires consist of semiconductor elements with approximately equal value. The difference is because of incompleteness of crystal networks. PL measurement of samples shows an X-ray and green wavelength. The green light could be resulted from oxygen vacancies in the zinc oxide nanowire. The vertical and uniform shape of nanowires and growing process without using catalyst are advantage of the proposed method. However other important results would be achieved by changing temperature, gas type or other factors.

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