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Research note

Synthesis and Characterization of Nanowires Zinc Oxide with Different Temperatures

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Abstract
Zinc oxide nano wire have been produced by simple thermal way heating Zn powder on alumina substrate at different temperatures from 600 ℃ to 1000 ℃ in furnace for a time period of 30 minutes under oxygen gas environment. The prepared samples were characterized by different characterizing techniques, scanning electron microscopy (SEM), X- ray Diffraction (XRD), energy dispersive X-ray spectroscopy (EDS), UV-Visible spectroscopy.In all photographs it is clearly seen that the growth of nano wires is initiated at outer surface of the ZnO porous grains. The growth is clearly started at the edge of the surface.The XRD characterization confirms the wurtzite hexagonal structure of synthesized zinc oxide.
The band gap of synthesized semiconductor Zinc Oxide is increased rather than the bulk Zinc Oxide.

Keywords: *Zinc Oxide Nano Wire, Thermal Way Heating, Characterization*

1. Introduction
The synthesis and characterization of various wide band gap metal oxides nanostructures such as nanowires, nanorods, nanobelts, nanobridges and nanowalls have attracted great interest due to their size, morphology-related properties, and their emerging applications in novel functional nanodevices (1,2). Recently, research and development of alternative energy technologies, such as low cost flat-panel solar cells thin film devices, and many other innovative concepts have increased. ZnO is an important multifunctional material which has received great attention during the last few years due to its unique applications in microelectronic and optoelectronic devices, and for self-assembled growth of three-dimensional nanoscale systems (3,4). Zinc oxide having a direct band gap of 3.37 eV and an exciton binding energy (60 eV) higher than those of ZnS (20eV) and GaN (21eV), is of interest for various high tech applications, such as optical devices (1), solar cells (5), piezoelectric devices (6), varistors (7), surface acoustic wave (SAW) devices (8), and gas sensors (9,10). Zinc oxide nanostructures have the potential to

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significantly improve the performance and durability of certain devices used in areas of importance: energy production and homeland security.

Zinc oxide (ZnO) is a unique material that exhibits semiconducting, piezoelectric, and pyroelectric multiple properties. Using a solid-vapor phase thermal sublimation technique, nanocombs, nanorings, nano-helixes/nanosprings, nanobows, nanobelts, nanowires, and nanocages of ZnO have been synthesized under specific growth conditions. These unique nanostructures unambiguously demonstrate that ZnO is probably the richest family of nanostructures among all materials, both in structures and properties. The nanostructures could have novel applications in optoelectronics, sensors, transducers, and biomedical science because they are bio-safe.

In the present work, we used a method to obtain nano wires ZnO by growth of ZnO nano wires by simply thermal heating Zn powder on alumina at different temperatures from 600°C to 1000°C in furnace for a time period of 30 minutes under oxygen gas environment. The prepared samples were characterized by different characterizing techniques viz. 1) XRD, 2) UV visible, 3) SEM etc.

2.Experimental

ZnO nano wires were prepared by thermal evaporation of a pure commercially available zinc metal powder in air without the presence of any catalyst under controlled heating temperatures, heating rates, room temperature loaded powder in furnace, direct loaded powder at high temperature in furnace, with or without passing oxygen gas in furnace. 3-4gr of a commercially available zinc metal powder (Zinc dust GR (LOBA CHEMI PVTLTD) 99.5% pure) was spread on alumina substrate. The powder spreaded substrate was loaded in a furnace (Bio-Techniques, India ISO9001:2001) which had a temperature range from 0°C to 1126°C for various time periods like 20 min, 30 min 40 min, 60 min, 80 min and for different temperatures from 600°C to 1000°C in the increasing steps of 50°C and for different heating rates 30°C/min, 50°C/min, 70°C/min, 100°C/min. During experimental, we discovered a simple approach to synthesize nano wires ZnO porous structure through controlling various parameters.

The as-prepared products were characterized and analyzed using scanning electron microscopy, X-Diffraction, energy dispersive X-ray spectroscopy, UV-Visiblespec-troscopy.The bulk x-Ray diffraction patterns were recorded on Philips X-Ray generator PW-1729. The X-Ray generator has a target of Cu, with a wave length of 1.54 A0. The measurements were carried out at room temperature with 20 ranging from 10 to 900. The d-value of each peak was calculated from Bragg's law and was compared with the ASTM data. The average grain size calculated from Scherer's formula is 28.9 nm.

The UV-Visible spectra of ZnO nano wires were recorded within the wavelength range 200 nm to 800nm and band gap was measured. The instrument used was JASCO V-670 Spectrometer.

3. Results and discussion

3.1 Direct loaded thick film at 700°C

In this photograph (Fig 1) taken by SEM

instrument, it can be seen that the growth of the nano wires started on the porous surface of the zinc oxide. In all the above photographs (Fig 1, 2, 3) it is clearly seen that the growth of nano wires is initiated at outer surface of the ZnO porous grains. The growth is clearly started at the edge of the surface. The most resolved nano wires structure are seen in Fig. 3. From this we can see that the wires wires grow vertically upward, with size decreasing towards the tip of the wires. The length of the nano wires is around 5-6 micrometer.

Figure 1. SEM image of direct loaded film at 700 at X5.

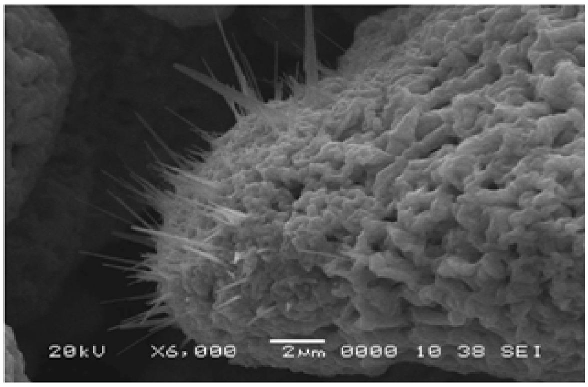

Figure 2. SEM iage of direct loaded film at 700 at X6.

3-2. Room temperature loaded thick film at 700°C

The photographs (Fig. 4, 5, 6) clearly show the length of the nano wires is long compared to the previous case 3.2.1 as observed. At this room temperature loaded thick film the growth of nano wires was observed, the length of the wires is 10-12 micrometer, but in the previous case it was observed to be 5-6 micrometer. It is also observed that the density of the nano wires is more in direct loaded thick film than the room temperature loaded film at 700°C.

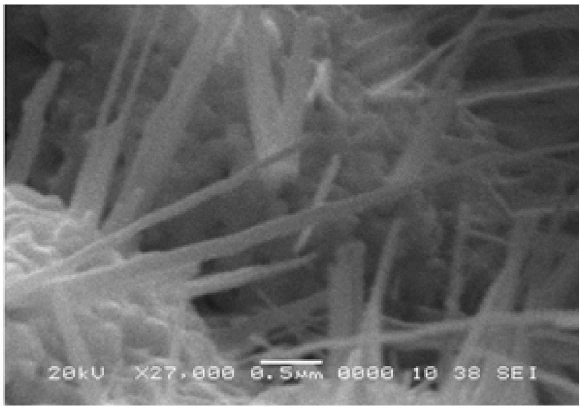

Figure 3. SEM image of direct loaded film at 700 at X2.

Figure 4. SEM image of room temperature loaded film at 700 at X3.

Figure 5. SEM image of room temperature loaded film at 700 at X8.

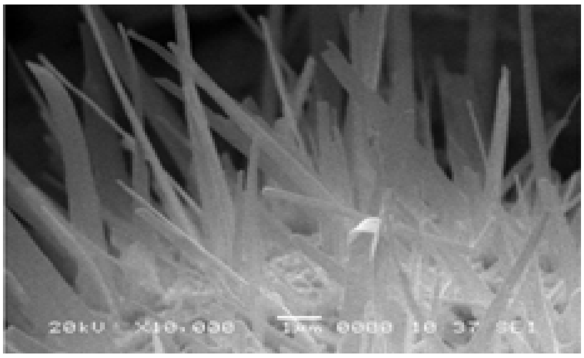

Figure 6. SEM image of room temperature loaded film at 700 at X10.

3-3. Room temperature loaded thick film at 1000°C

The room temperature loaded film at 1000°C of SEM images in the above Figs. 7, 8, 9 shows the nano wires have grown outward from the Zinc Oxide porous structure. Their shape is like a needle. The part other than nano wires is porous structure of Zinc Oxide.

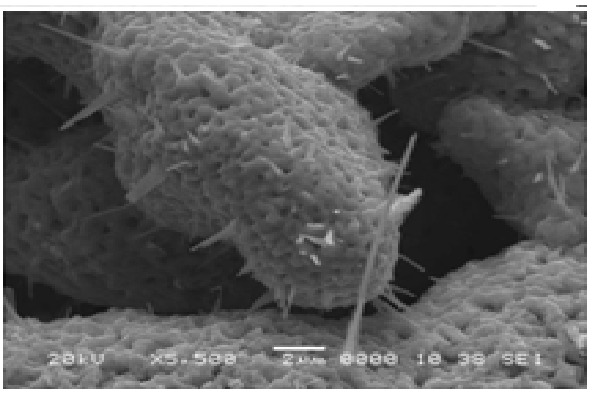

Figure 7. SEM image of room temperature loaded film at 1000 C at X5.

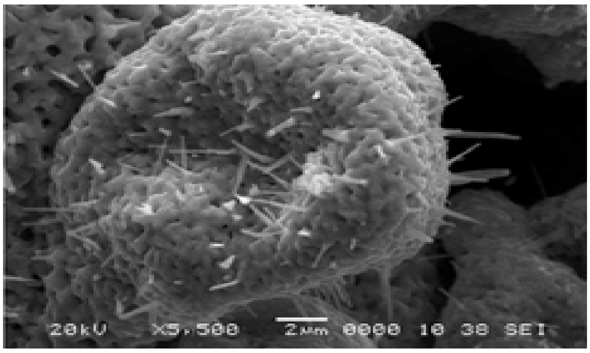

Figure 8. SEM image of room temperature loaded film at 1000 C at X5.

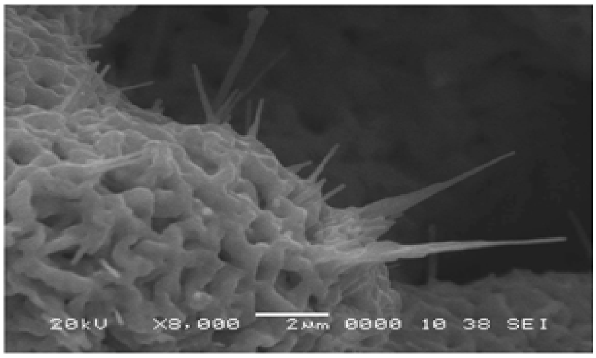

Figure 9. SEM image of room temperature loaded film at 1000 C at X5.

3-4. XRD analysis of Zinc Oxide

X-ray diffraction pattern of ZnO films was carried out from 20^0 to 90^0. Fig 10 shows XRD pattern of the Room Temperature Loaded thick Zinc Oxide film. All the major peaks were identified by Bragg’s law and were found to be hexagonal Zinc Oxide. The structure and composition studies of different samples were analyzed by the bulk X-Ray diffraction, (Philips X-ray generator PW-1729). The X-ray generator has a target of Cu, with a wavelength of 1.54 A^0. The measurements were carried out at room temperature. The average grain size calculated from Scherrer’s formula is found to be 29 nm.

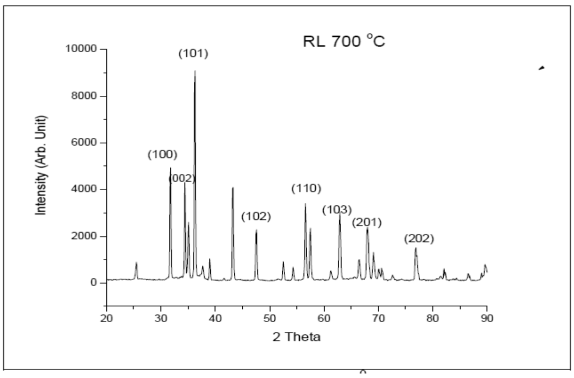

Figure 10. XRD pattern of RL 700°C.

3-5. UV-Visible spectroscopic analysis of Zinc Oxide

The above UV-Visible spectra (Fig 11) shows a shift in the wavelength of direct loaded and room temperature loaded films. These wavelengths are smaller than the bulk semiconductor zinc oxide (375 nm at room temperature), i.e. the band gap of synthesized semiconductor Zinc Oxide is increased more than the bulk Zinc Oxide. The band gap of DL700 is calculated and is 3.51 eV and that of RL 1000 is 3.49 eV. The band gap of material increases when the size of the semiconductor material decreases. So from the band gaps of the calculated samples, we can conclude that the size of the material is decreased.

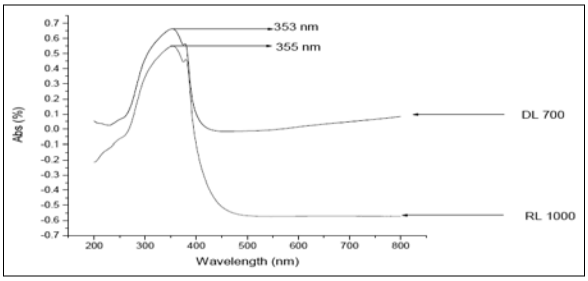

Figure 11. UV- visible spectra of direct loaded at 700°C (DL700) and room temperature loaded at 1000°C (RL1000) film of zinc Oxide.

4. Conclusions

In this project we have successfully synthesized zinc oxide nano wires on the micron size porous grains of zinc oxide, by a simple thermal method. The synthesis method used in our case is very simple, requires less instrumentation, but is a very efficient method to grow ZnO nano wires of various lengths (1 to 15 μm) and diameters (20 to 150 nm). Various synthesis parameters are optimized for the growth of nanowires. During synthesis, different parameters are varied, such as loading film in furnace at room temperature and then start increasing temperature of the film to a particular temperature for a fixed time, direct loading sample in the furnace at some fixed temperatures for a fixed time, time of the film for the different temperatures and the temperature. Oxygen gas flow in the furnace for different temperatures and for different fixed times and temperature rate of the furnace are also varied.

By varying the above parameters, nano wires are grown on the surface of porous of zinc oxide for the direct loaded film at 700°C. Nano wires are also obtained for the films of room temperature loaded films at 700°C and 1000°C, but nano wires are more dense for the direct loaded film in furnace at 700°C and all over the surface of the film.So for this method synthesis of Zinc Oxide nano wires Direct loaded film in the furnace at 700°C is the optimum condition to obtain nano wires. UV-Visible and X-Ray characterizations show the band gap of synthesized zincoxide is increased and average grain size decreased respectively.

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