

Plant Mediated Synthesis of Zinc Oxide Nanoparticles for Nanoelectronics

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ABSTRACT: This paper reports the studies on the synthesis of nano-sized Zinc oxide (ZnO). The plant mediated synthesis method was used to synthesize nano-sized ZnO powder using zinc nitrate and the aloe vera plant extract, as starting materials and water as a carrier. The resulting nano-sized powder was characterized by x-ray diffraction (XRD) measurements, field emission scanning electron microscopy (FE-SEM) and the transmission electron microscopy (TEM). The simple green synthesis method was used and precursor was calcinated at 400^oC to obtain nano-sized ZnO. It was found that the calcinations temperature and the concentration of plant extract significantly affect the size of the nano-sized ZnO powder.

KEYWORDS: ZnO nanoparticles, Plant mediated synthesis, XRD, TEM.

1. INTRODUCTION

Among the various metal oxides much attention has been paid to nanocrystalline materials. This is due to their promising properties, such as applications in sensors, lithium ion batteries, super capacitors. In recent years, the synthesis of nano-crystalline oxide materials has been a focal point of research and developmental activities in the area of nano-materials owing to the quest for their various technological applications [1-7]. Semi conducting metal oxides such as SnO₂ [8], WO₃ [9] and Fe₂O₃ [10] have been widely used as gas sensing materials for the detection of inflammable and toxic gases. The sensor performance is strongly dependent on the micro structural features such as crystallite size, grain boundary characteristics and thermal stability. Several approaches have been explored to fabricate the sensors with an improved performance, which include nano-sized crystallites [11,12], solid solution [13,14] and additives or surface functionalization [15,16].

ZnO is degenerate, n-type semiconductor and it has interesting properties like large band gap, low electrical resistivity, high transmission in the visible region etc; which make it useful for a wide range of applications such as photodiodes [17], phototransistors [18], photovoltaic cell [19], transparent electrodes [20], liquid crystal displays, IR reflectors and anti-reflection coatings [21]. To the best of our knowledge, there are no reports in the literature dealing with the use of ZnO as sensing material for the fabrication of the gas sensors. However, it was reported that the ZnO could be used as the dopant to improve the sensor performance. Zhang Tianshu studied the influence of Zn dopant on the gas sensing properties of SnO₂ to C₂H₅OH and hydrogen. It was shown that the Zn doping causes a remarkable improvement in the response of SnO₂ to C₂H₅ and H₂. [22,23,24].

With the objective to synthesize ZnO using plants as crystal growth modifier, we have made an attempt to synthesize nano-sized ZnO by a simple and cost effective plant mediated synthesis method.

II. EXPERIMENTAL

The nano-sized powder of ZnO was prepared by a simple and cost effective plant mediated synthesis method. In this method, a zinc nitrate solution was used to synthesize ZnO. In this work, the aqueous solution of 0.5 M zinc

nitrate was prepared in aloe vera plant extract which was prepared in double distilled water. This solution then heated in a petry dish at 90°C upto the precursor gets dried. The dried powder then calcinated at 400°C for 2 hours to get the pure zinc oxide nano powder.

The structure of the calcined powder was investigated by using X-ray diffraction (XRD) technique. The X-ray diffraction patterns were recorded with a Rigaku diffractometer (Miniflex Model, Rigaku, Japan) having Cu K_α (λ = 0.1542 nm). The crystalline size was estimated using Debye-Scherrer's formula. The transmission electron microscopy (TEM) was used to determine the particle size and the morphology of the nano-sized powder with JEOL 1200 EX. For the conformation of d-values the electron diffraction pattern was recorded. The FE-SEM analysis of ZnO powder was carried out to confirm the size and morphology of synthesized ZnO.

III. RESULTS AND DISCUSSION

A. SURFACE MORPHOLOGY

The FE-SEM image of the calcined ZnO powder is shown in Fig.1. As can be seen from Fig.1 the formation of the nano particles of very small in size (6-8 nm) which confirm the formation of the ZnO nanoparticles of very small in size (6-8 nm).

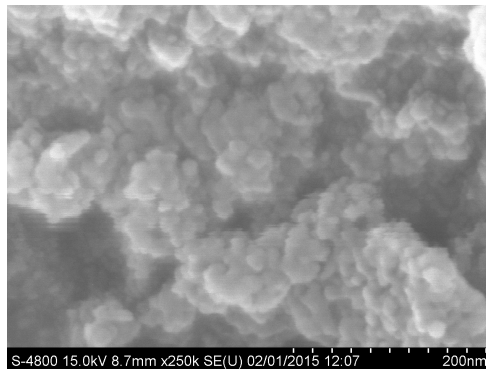


Fig. 1 Field emission scanning electron microscopy (FE-SEM) pattern of ZnO calcined at 400°C for 2 hrs

The XRD pattern of the calcined powder at 400°C for 2 h is shown in Fig.3. It indicates the diffraction peaks at 2θ values of 30.78°, 34.29°, 35.34° and 54.74°, which are attributed to the formation of ZnO. The crystal structure is hexagonal and all the d-line patterns match with reported values. The crystallite size was calculated by using the Scherrer formula –

$$t = \frac{k\lambda}{B \cos \theta}$$

where t is the average size of the crystallite, assuming that the grains are spherical, k is 0.9, λ is the wavelength of X-ray radiation, B is the peak full width at half maximum (FWHM) and θ is the angle of diffraction. The crystalline size of the powder calcined at 400°C is found to be ~ 8.20 nm.

The TEM micrograph of the powder calcined at 400°C along with the electron diffraction pattern is shown in Fig.4. The TEM micrograph shows clearly that the particle size of powder calcined at 400°C is ~ 8 nm. This result is in we

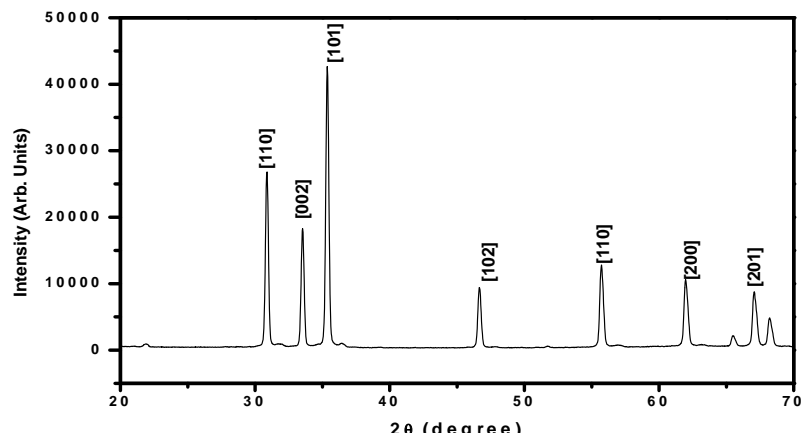


Fig. 2 XRD pattern of the ZnO powder calcined at 400°C for 2 hours

All agreement with the crystallite size calculated using the XRD data. The ED pattern gives the d spacing consistent with those obtained from XRD data.

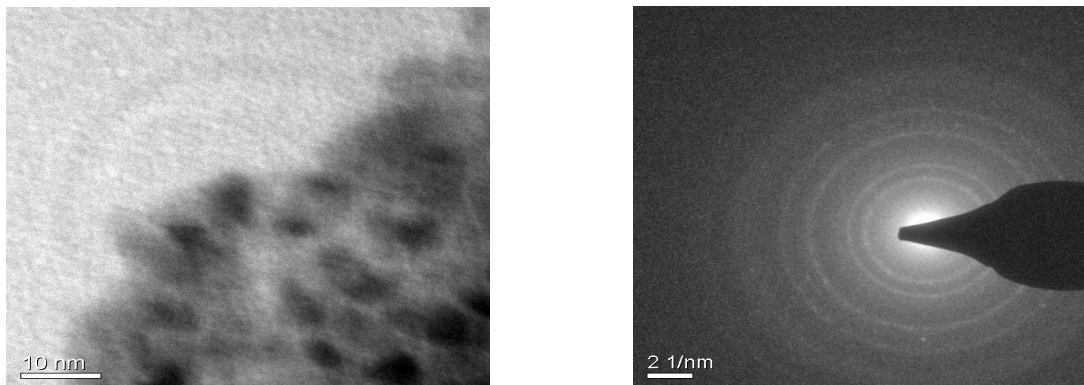


Fig. 3 TEM micrograph and electron diffraction pattern of ZnO calcined at 400°C for 2 hours

In order to study the effect of the plant extract on the crystallite size, the as-prepared powder was calcined at 400°C for 2 h in air. The variation of the crystallite size on the concentration of plant extract will also be studied. The crystallite size is found to be smallest when the as-prepared powder was calcined at 400°C for 2 h. This observation is consistent with crystallite sizes obtained from XRD patterns (not shown here). This observation may be attributed to the particles growth and a lot small particles aggregation after being calcined at higher temperatures.

IV. CONCLUSIONS

We have successfully synthesized the ZnO nanoparticles at low cost by using a plant mediated synthesis method using aloe vera plant extract as a crystal growth modifier and by calcination of zinc hydroxide precursor in air we get the pure zinc oxide nanoparticles. The FE-SEM and TEM study revealed the formation of nanoparticles having the size of ~6-8 nm.

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