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Novel Technique to Deposit Thin Films of Nanoparticles

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Abstract: Thin films of semiconducting nanoparticles have tremendous applications in electronics industry, solar cells and gas sensors. In the present work, we have used Microwave Irradiation Technique to synthesize Zinc oxide nanoparticles. These were subsequently annealed at 400°C. The crystalline nature and size of these particles were determined from the XRD spectra. Thin films of varying thickness of the synthesized nanoparticles were obtained using a novel deposition technique. This technique is an indigenous modification of the spin coating technique. Uniform thin films of desired thickness could be obtained by restricting the number of deposition cycles. Uniform distribution of the particles was confirmed from the AFM data. The thickness of the film was found to be in the nano range. The UV spectrum of the film was used to determine the band gap energy. These results are discussed in the present report.
Key Words- Thin films; Nanoparticles; Modified Spin Coating.

1. Introduction and Experimental Details:

Being simple and cost effective, spin coating is the most very widely used technique for depositing thin films. However there are a few limitations in the spin coating technique. In the present work, we have used a modified spin coating technique [1] to obtain uniform thin films of nanoparticles. A normal spin coating device uses a single substrate and the solution is open to atmosphere. Air that is in contact with the solution co-rotates. Viscous solution is necessary in this method. In the modified technique[2], two substrates are used that are placed one over the other with micron spacers in between. Thus the substrates form a reservoir in between that holds the solution. The air in contact with the solution counter rotates and hence less viscous or aqueous solutions can be used to deposit thin films. The thickness of the film can be controlled by restricting the number of iterations.

Zinc oxide is an n-type semiconductor having wide band gap energy (3.3 eV) and large exciton binding energy (60 mV) [3]. Zinc oxide nanoparticles have wider band gap energy. Due to the large specific area, less toxicity and low cost, it can be used as a catalyst and a chemical absorbent.

Zinc oxide nanoparticles were prepared by microwave irradiation method. Aqueous solutions of zinc acetate and sodium hydroxide were mixed together in the molar ratio of 1:2 and stirred for several minutes. This solution was microwave irradiated for 15 minutes. After cooling to room temperature, the solution was centrifuged with distilled water and ethanol to remove all impurities. The precipitate was then dried overnight in air. The dried powder was calcined at 400°C for two hours. The as-prepared sample was characterized by XRD that revealed the existence of ZnO nanoparticles.

Glass substrates used to deposit thin films of ZnO nanoparticles were cleaned by dipping them in freshly prepared Piranha solution for 24 hours, washed with plenty of distilled water and dried. Two substrates were mounted on the assembly with spacers in between. ZnO nanoparticles dispersed in ethanol were introduced between the substrates and the assembly was rotated at 2500 rpm for one minute. 10 to 20 such iterations were carried out to obtain thin films of varying thickness. These films were characterized by UV and AFM.

2. Results and Discussion

2.1. XRD Spectra:

Fig. 2.1 shows the XRD spectra of the microwave synthesized particles. This spectrum matches well with JCPDS data (No.050664). Thus ZnO phase has been formed with hexagonal structure having a = b = 3.249 Å and c = 5.205 Å. The width of peaks is a clear indication of the formation of nanoparticles. The size of the particles has been obtained using Debye Sherrer formula and is found to be 38.7 nm.

2.2. UV Spectra:

Fig. 2.2 shows the absorption spectrum of the ZnO film obtained using the Modified Spin Coating technique. A clear absorption peak appears at 368 nm with band gap energy of 3.4 eV. The bulk band gap energy is 3.3 eV. Thus an increase in the band gap energy with decrease in size is clearly obtained.

2.3. AFM data:

The AFM data of the ZnO films deposited on the upper and lower substrates are shown in fig.2.3. The AFM images show uniform nature of the films. As expected the upper film shows better uniformity than the lower one. The average thickness appears to be about 60 nm. Since the average size is about 40 nm, it indicates the formation of a monolayer or at the most a bilayer. Thus, with this modified technique of spin coating we can readily obtain uniform thin films of nanoparticles of desired thickness.

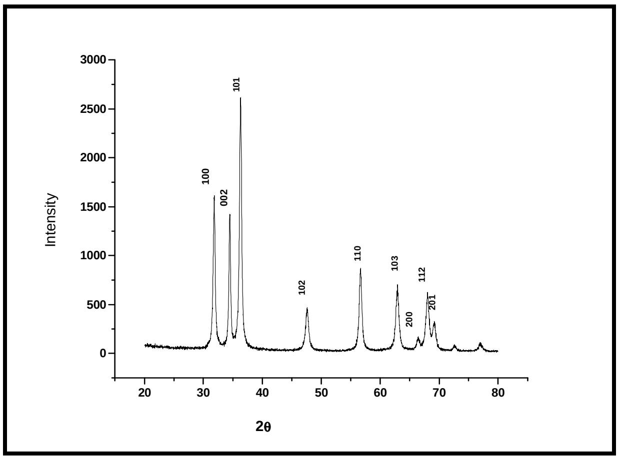

Fig: 2.1: XRD spectrum of ZnO Nanoparticles

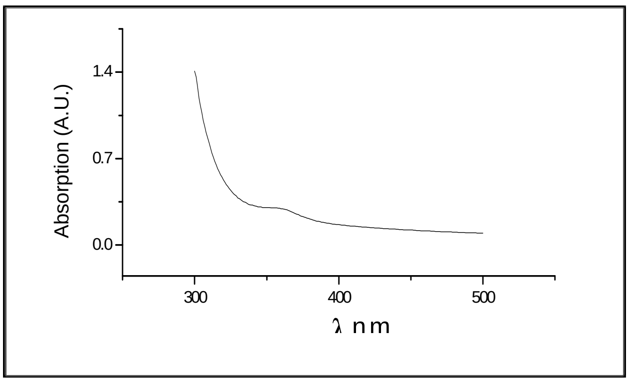

Fig. 2.2: UV spectra of ZnO film

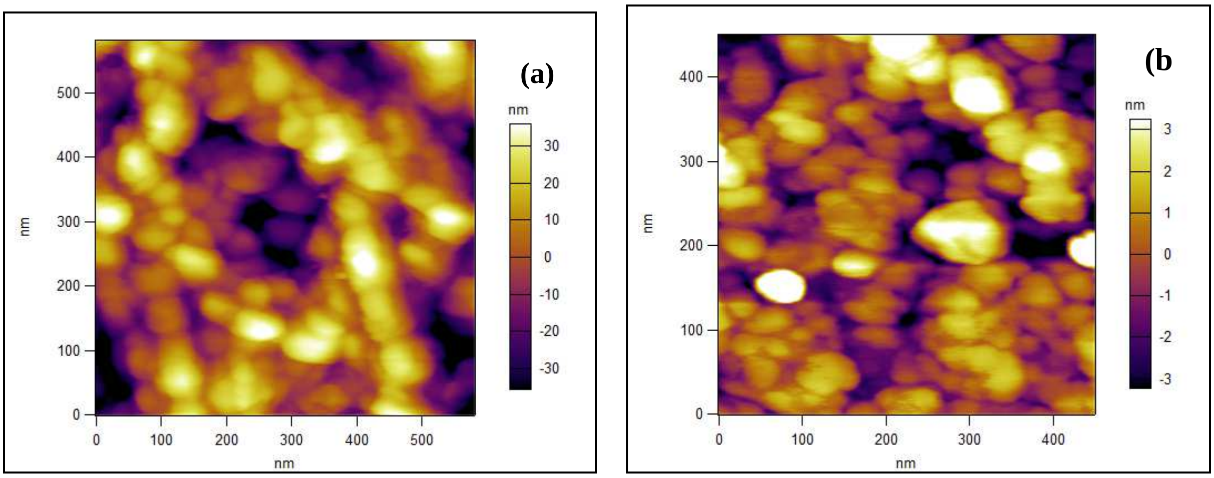

Fig. 2.3 :AFM images of film on a) lower substrate and b) upper substrate

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