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# Effect of ECR Plasma Treatment on ZnO Thin Films

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## ABSTRACT

*ZnO nanoparticles were synthesized by sol-gel method. Zinc acetate dehydrate and monoethanolamine (MEA) were used as the precursor materials. The Zinc Oxide (ZnO) thin films were prepared by spin coating technique. The obtained films were further calcined at 500oC. The X-ray diffraction (XRD) technique was used to characterize the thin films. The XRD spectra indicate that the ZnO crystal has a hexagonal wurtzite structure. The grain size of 16nm was obtained from the analysis of XRD pattern. The wettability of thin film was determined by measuring the contact angle. A home-made electron cyclotron resonance (ECR) plasma was used to study its effect on the surface modification of ZnO thin film. The ZnO thin film was treated with Ar-plasma for 20 min. The plasma treatment resulted in the surface modification of ZnO thin films which was observed from the changes in the contact angle measurement.*

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## INTRODUCTION

Surface engineering is carried out in order to attain superior performance and durability of a substrate. Wetting phenomenon is one such property which deals with the identification of the surface modification [1]. Wettability is strongly affected by the chemical composition and geometrical structure of the solid surface. Wettability has potential application in self- cleaning materials, drag reduction coating, anti-fogging and so on [2,3].

Zinc oxide (ZnO) is a wide-band gap semiconductor which has several favourable properties like high electron mobility, good transparency, and strong room temperature luminescence. ZnO basically crystallizes into two main forms, cubic zinc blende and hexagonal wurtzite [4]. The stable structure which is most common is wurtzite. ZnO can be synthesized in variety of ways with different particle structures and finds potential applications in various fields of technology.

There are various ways to synthesize ZnO thin films ranging from the sol-gel method to pulsed laser deposition. The sol-gel process offers other advantages such as high surface morphology, easy grip over the chemical components and good optical properties of ZnO thin film. Sol-gel method is widely used for the synthesis of oxide materials due to its simplicity and cost effectiveness [5].

In the present work nano-crystalline ZnO thin films were prepared by sol-gel spin coating technique using zinc acetate precursor. These films were further treated with ECR Plasma to induce surface modification. The surface morphologies and optical properties of the as synthesized ZnO film were studied.

## EXPERIMENTAL

### ZnO Sol-Gel Preparation

ZnO thin films were coated on glass substrates by sol-gel method. Zinc acetate de-hydrate, 2-methoxyethanol and monoethanolamine (MEA) were used as precursor, solvent and stabilizer respectively. Zinc acetate de-hydrate and 2-methoxyethanol were mixed together and stirred magnetically for 50 min at 80°C. Further, MEA was added under constant stirring and stirred for 90 minutes to yield a colourless, homogeneous and transparent solution. The solution was aged for 72 hours at room temperature in order to make it more glutinous.

### Deposition of Thin Films

The glass substrates were sonicated for 30 min and then cleaned in acetone. Afterwards, substrates were rinsed with distilled water. The aged ZnO solution was dropped on glass substrates which were rotated at 2000 rpm for 30 seconds. The deposited films were then pre-heated at 150°C for 5 minutes into an oven. This spinning to pre-heating procedure was repeated for fifteen times (layers). Finally, the films were annealed at 500°C for 3 hrs to remove all the unwanted organic species.

### Ar-ECR Plasma Treatment

The ECR system was pre-evacuated and feed with respective gases till operating pressure is obtained. The plasma is generated in the reaction chamber when the resonance conditions are satisfied for the input electric frequency of 2.45 GHz to the magnetic field of 875 G. The Ar-ECR plasma was generated was exposed it onto a ZnO film for 20 min. The samples were placed at a distance of 15 cm from the ECR zone.

The structural properties of ZnO films were characterized by XRD using Bruker advance diffractometer with Cu-Kα radiation. The contact angle measurements of water were obtained for the ZnO films to determine whether the films are hydrophilic or hydrophobic in nature.

## RESULT AND DISCUSSION

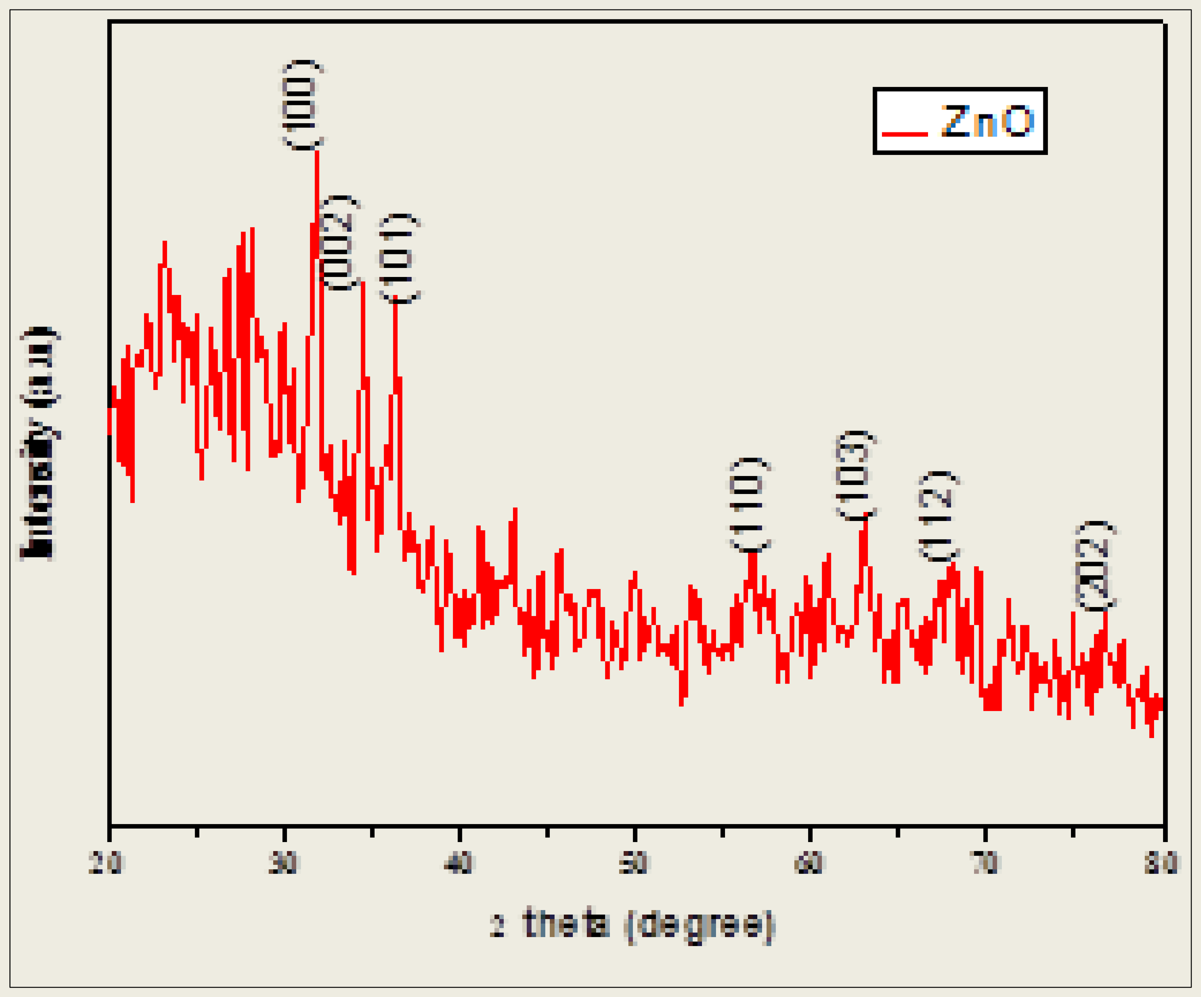


**Figure 1: XRD of ZnO thin Film calcined at 500°C**

Fig 1. shows the XRD pattern of ZnO thin films. The different peak orientations were observed along the (100), (002), (110), (103), and (112) planes. The obtained peaks confirm the formation of ZnO particles with hexagonal wurtzite structure. The crystallite size (D) of the synthesized ZnO nanocrystals was calculated using the Debye-Scherrer formula. The calculated average value of crystallite size is found to be 22.9nm.

Fig 2. shows the contact angle measurement of water drop on glass, ZnO film and plasma treated ZnO film. Contact Angle of DI water on Plain Glass Substrate is found to be 26.20° and on ZnO Thin Film is found to be 100.27°. Thus it can be observed that the ZnO thin films have considerable effect of Ar-ECR plasma on its surface.

## CONCLUSIONS

The Ar-ECR plasma has sufficient energy to cause surface modifications in ZnO thin Films. It can be concluded that due to plasma treatment the ZnO thin films surface is modified from hydrophobic to hydrophilic which is desirable for self-cleaning application.

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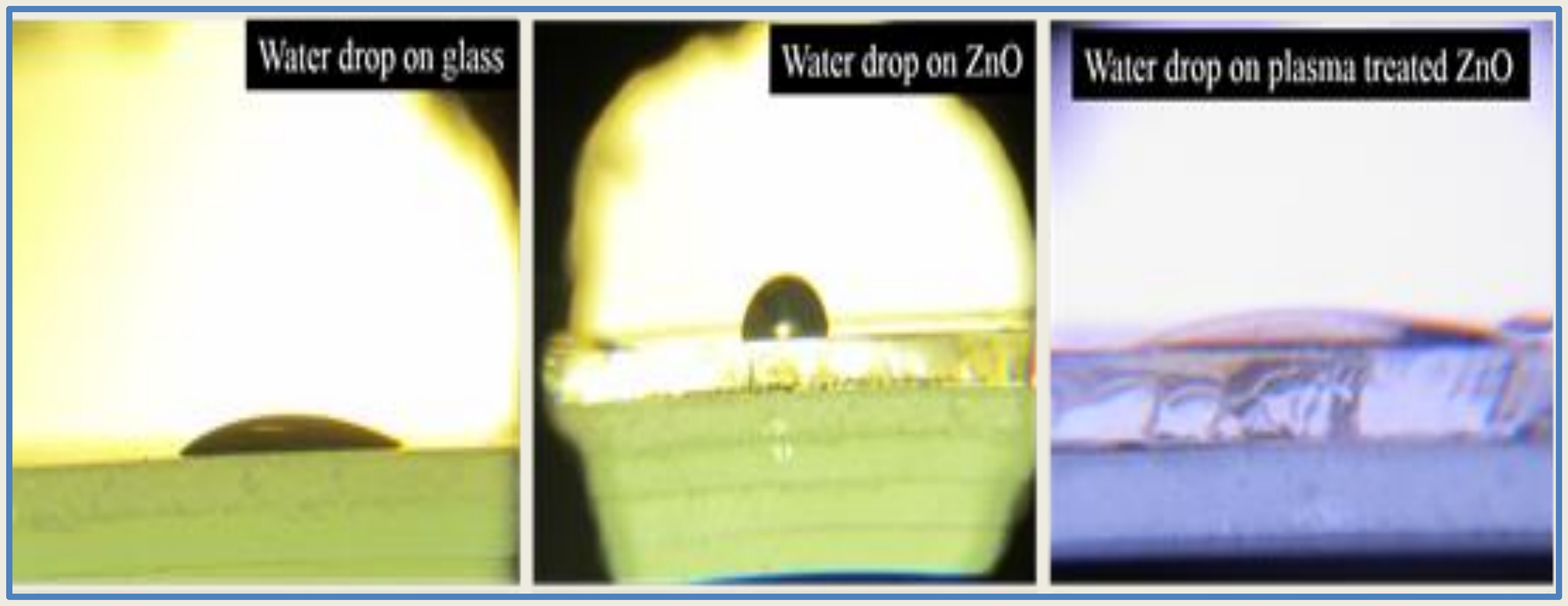


**Figure 2: Contact angle measurement of water onto glass, ZnO film and plasma treated ZnO film**