Frequency Dependant Electrical Characterization of ZnO Thin Film on Aluminum Substrate prepared by Sol-gel Technique

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***Abstract*—Zinc Oxide (ZnO) compound is a crystalline form of hexagonal wurtzite structure. Its unique chemical and physical properties such as wide band gap energy, high piezoelectric property, stable molecule absorption characteristics and optical catalyst functions are exploited for use in chemical sensor, industrial monitor, medical application and biosensor. In this present work the frequency response of sol-gel prepared ZnO coated on aluminum substrate are presented. The sample was detected as n-type by hot probe method. The frequency dependence electrical characterizations such as inductance, resistance, capacitance and impedance of the specimen were studied using LCR Meter. From this study we find that capacitance and impedance decreases with increase of frequency, but inductance and resistance are independent of frequency. In addition, the uniform coated morphology of oxide film on the substrate was observed by high resolution optical microscope.**

***Index Terms*—P-type Zinc oxide, Zinc-coated aluminum, sol-gel Technique, LCR meter**

I. Introduction

Zinc oxide (ZnO) is a material of great interest for high temperature, high power electronic devices either on the form of bulk as an active material or as a substrate for epitaxial growth of group III compounds. It has high energy-gap of about 3.3 eV and high excitonic binding energy (60 meV) [1], [2]. Furthermore, it is the most common material used in the commercial manufacturing and research due to its low cost processing and wide availability. ZnO may be of n-type or p-type depending on the ZnO material processing. For ZnO, n-type conductivity is relatively easy to realize via excess Zinc or with Aluminum (Al) doping; whereas, p-type doping has only recently been achieved. ZnO films are deposited by different methods such as sol-gel [3], DC and radio frequency (rf) sputtering [4]-[7] method etc. The surface structure of ZnO thin film is prepared by sol-gel double side spin coating technique [3]. Thereafter, the electrical properties like resistance, inductance, capacitance and impedance with respect to frequency were measured [8].

II. Materials Preparation and Electrical Characterizations

A. *Sol-gel Process for ZnO*

For the preparation of ZnO solution by sol-gel method [3], [8], [9], 4.40 gms of zinc acetate dihydrate was first mixed with ethylene glycol (10 ml) and glycerol (5-7 drops) at room temperature. The mixed solution was stirred by magnetic stirrer at a constant temperature at 110 ℃ till the solution becomes transparent positively. Then, off stirred and cooled down the solution to room temperature and thereafter 2-proponal (15 ml) and Tri-Ethyl-Amine (4 ml) were added slowly, so that no turbidity is formed. Further, the solution is heated till it becomes gel. This yields a clear and homogenous solution, which served as the precursor solution.

B. *Thin Film Preparation and Heat Treatment*

ZnO thin film was prepared by sol-gel spin coating method onto an Aluminum piece of 0.005 m × 0.003 m × 0.00072 m. In atmospheric environment, this aluminum substrate is coated by ZnO sol-gel by spin technique at 3000 rpm for 90 sec. The ZnO thin film coated on Aluminum substrate was heated inside an oven to dry its surface. Once the desired ZnO film is achieved, the substrate is now heated at 450 ℃ for 2 hours. This yields to a film of thickness around 45 µm. The zinc oxide-coated aluminum specimens were rinsed in distilled water and methanol, dried in hot air, and then placed in desiccators prior to electrical characterizations.

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III. Results and Discussions

A uniform oxide film owing to thermal by oxidated of the zinc coating is observed by high resolution optical microscope [Axiovert 40 MAT of 1000x]. Generally, it was observed that the surface of the zinc coating had become more oxidized, resulting a darker color, as shown in Fig. 1

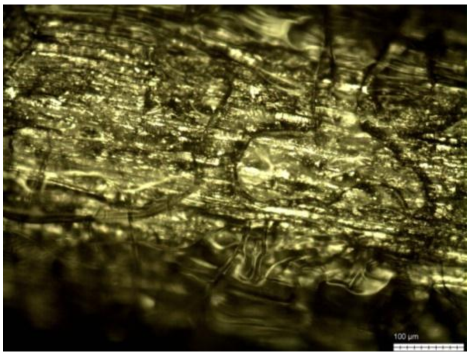

Figure 1. Morphological structure, which is generated from high resolution optical microscope

The sample shows n-type by hot probe method. The I-V graph for ZnO-Al thin film at temperature 1600C was determined by using four probe methods. The nature of contact is shown omic which is shown in Fig. 2. That infer n-type ZnO and Al contact is ohmic.

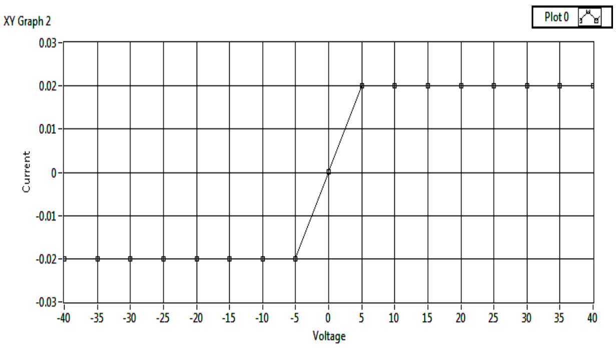

Figure 2. I-V graph of ZnO –Al thin film

The electrical characterizations, such as inductance, resistance, capacitance and impedance of the specimen were studied using LCR Meter (PSM 1735, 4th Newton Limited. UK):

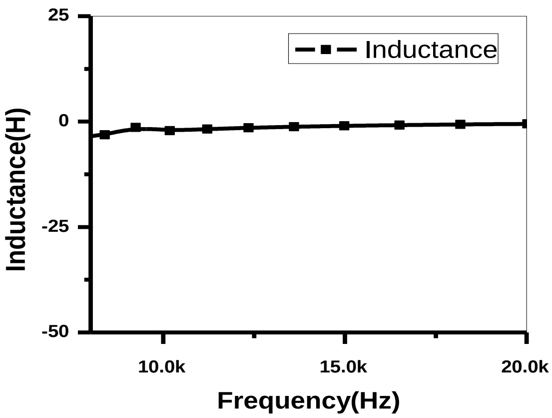

Figure 3. Frequency Vs Inductance

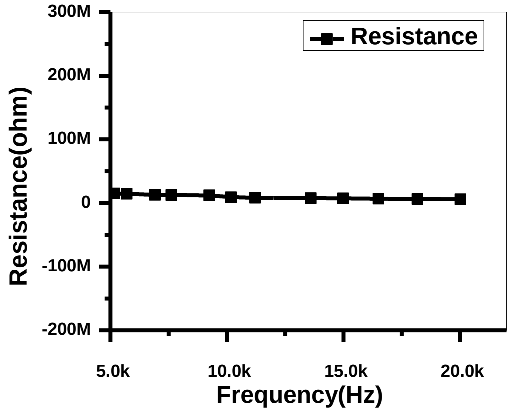

Figure 4. Frequency Vs Resistance

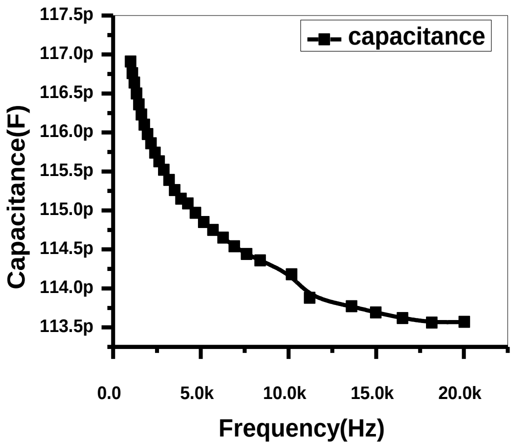

Figure 5. Frequency Vs Capacitance

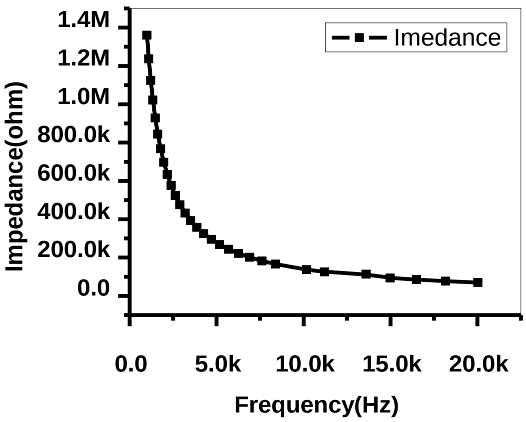

Figure 6. Frequency Vs Impedance

In Fig. 3, it was found that inductance almost becomes independent of frequency. Since the inductance is almost zero, the specimen has no magnetic property. Hence, it can be used in different insulator applications. In Fig. 4, resistance shows a constant behavior as the frequency increases means it is also independent of frequency. In Fig. 5, capacitance smoothly decreases exponentially with frequency.

In Fig. 6, impedance decreases exponentially. At higher frequencies, impedance (Z) is independent of R and L but depends upon C. So, its characteristics curve is approximately similar to that of capacitance curve.

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IV. CONCLUSIONS

The Zinc Oxide layer was coated as the protective covering over the aluminum substrate by spin coating technique and followed by heat-treatment. A uniform oxide film surface morphology was observed by high resolution optical microscope. All the samples show p-type. The frequency dependent electrical characterizations, such as inductance, resistance, capacitance and impedance of the specimen were studied using LCR Meter. From this study we find that capacitance and impedance decreased with increased of frequency. The resistance and inductance are independent of frequency up to 20 kHz. This shows that the prepared sample is non-magnetic in nature and it will be a good material for capacitive application at low frequency range.

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