Investigation of structural, optical and electrical properties of Zinc Oxide (ZnO) thin film on Silicon (Si) substrate using RF Magnetron sputtering approach

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In recent years, there is rapid increase in the number of investigations on zinc oxide (ZnO) has been noticeable. It is a promising material for variety of optoelectronic and piezoelectric device applications because of its unique properties especially wide band gap of 3.37 eV based on investigation by Jandow et al. [1]. ZnO has large exciting binding energy of 60 eV at ambient temperature as investigated by Umar et al. [2] which is useful to for many applications. Also ensures its suitability as photo detectors (UV), room temperature LEDs, solar cells and gas sensors [3–6]. ZnO is widely used as transparent conducting material in large number of transparent conducting films (TCF's). There are different techniques such as sol–gel, thermal vapor deposition, pulsed laser deposition, e-beam deposition and RF sputtering has been reported for growing ZnO thin films [7–10]. Among these methods, RF sputtering is a very useful technique for the deposition of ZnO. Because in RF sputtering technique, different parameters such as pressure, temperature, deposition time, gas flow rate and RF power can control the properties of grown thin films. The selection of substrate material is an important factor required for the deposition of ZnO thin film. Different types of substrates that are used to deposit ZnO thin films consist of PPC plastic [1], sapphire (Al_2O_3) [11], soda lime glass [12], Si [13], GaAs [14], and polyimide [15]. Here, we have deposited ZnO on Si (silicon) substrate and further we are going to fabricate metal-dielectric multilayers for various optoelectronic applications.

The objective of this work is to study the effect of structural, electrical and optical properties of ZnO thin films grown on silicon substrate. The structural properties were characterized by X-ray diffraction (XRD), surface analysis was done by using atomic force microscopy (AFM), electrical properties by Hall measurements and optical properties were analysed by using Raman spectroscopy.

In this research paper, we have successfully deposited Zinc Oxide (ZnO) single layer of 100 nm on silicon (Si) substrate using radio frequency magnetron sputtering approach. Base pressure of 1.0×10^{-5} mbar, RF power of 100W at Ar flow 15sccm and room temperature were taken as process parameters. In characterization of ZnO layer deposited on Silicon substrate, X-Ray diffraction (XRD) confirms the crystalline nature of ZnO with different sharp peaks and average crystallite size was found to be 108.16 nm using Scherrer's formula. The average surface roughness (Ra) and root mean square roughness (Rq) of ZnO were 2.75 nm and 3.70 nm respectively using Atomic Force Microscopy (AFM) technique. The resistivity and sheet resistance of the ZnO layer were characterized by Hall measurements at room temperature. The sheet resistance of the layer was measured to be 7.05×10^{3} Ω/sq and resistivity was 7.05×10^{-2} Ωcm. Raman and Photoluminescence spectroscopy were used to analyse optical properties. PL signal detects the emission peak of the ZnO deposited on silicon substrate corresponds to 380.30 nm (E_g = 3.26 eV). The results exhibited that the Zinc Oxide (ZnO) thin film grown on Silicon substrate (Si), ZnO/Si has good quality.

References

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