Electrical and Optical Properties Silver Oxide Thin Films by Using RF Sputtering Technique

Shivakumar Siddanna[1], Devidas G. B[2], S M Hanagodimath[3]
[1, 2] Dept of Physics, Kuvempu University Shankaraghatta, Shimogga – 577 451
[3] Dept of Physics ,Gulbarga University Kalaburagi ,Kalaburagi -585106

Abstract

Silver oxide is an efficient material, because it is used in batteries. Apart from this, it is a moderate oxidizing agent in a variety of processes, including the oxidation of aldehydes to carboxylic acids. It is also employed in the synthesis of numerous chemicals, to make Tollen's reagent, solar cells, and disinfectant coatings. Silver oxide (Ag_2O) films were fabricated on etched Fluorine-Tin Oxide (FTO) glass using the radio frequency sputtering technique and annealed at 200° C for two hours. The thicknesses of all the films were estimated using a 3D non-contact optical profiler in the thickness interval of 42 nm-660 nm. The I-V characteristics were measured at room temperature, and it was found that as the thickness of the film increases, the electrical resistivity also increases. Then these films were subsequently exposed to optical characterization, revealing exceptionally low transmittance and high absorbance. The band gap is estimated to be 2.51 eV. The X-ray diffraction (XRD) studies reveal that the material is crystalline, and Miller indices have also been identified. The morphology and topography of the thin films were analyzed using a Field Emission Scanning Electron Microscope (FESEM), and the chemical composition was estimated using EDS. We have determined electrical resistance by a Van der Pauw method and then it is used DK2 Ratio recording Spectrophotometer to analyze absorption and transmission data. The present work reveals that the optical and electrical properties are highly dependent on the thickness and material distribution.

Introduction

Silver (Ag) is commonly thought of as a non-reactive substance. Silver Oxide (Ag2O) has been discovered to be a p-type semiconductor with an energy gap of roughly 1.2 . The Ag2O nanoparticles have numerous applications because of their outstanding antimicrobial actions, good conducting and optical characteristics, and their main application for solar cells. It has been discovered that the size and shape of Ag2O have a significant impact on its optical characteristics. Due to the fact that silver nanoparticles are used in batteries, the spectral response of these particles in the visible range of the electromagnetic spectrum has garnered even greater attention. It functions as a mild oxidizing agent in numerous processes, such as those that convert aldehydes to carboxylic acids. Several different chemicals can be synthesized with it. It is also employed in the creation of Tollen's reagent. Films are attracted by scientists for their novel application and intense density optical storage gadgets, gas sensors, solar cells, and disinfectant coatings. Hence, we have made a systematic investigation on the electrical and optical properties of silver oxide thin film coatings in the thickness range (42-660) nm. The films were grown in a conventional vacuum coating unit under a base pressure of 3x10-6 mbar.

Design/Other information

Methodology :
Silver oxide thin films were prepared and deposited onto Fluorine doped Tin oxide (FTO) glass substrate using a radio frequency magnetron sputtering technique(1) . A silver target of 99.9% purity was used as a sputtering target the base pressure was around 3x10-6 mbar obtained in the sputter chamber using a diffusion pump backed with rotary pump assistance. Argon was used as a sputter gas, and oxygen was employed as a reactive gas(2) . The requisite volumes of reactive gas, Oxygen, and sputter gas Argon were permitted to enter the sputter cabin by a fine-regulated needle valve, with a spacing of roughly 70 mm between the target and the substrate material. The advanced radio frequency energy source was used to power the sputter target. The sputter target received 80 watts of electricity. At ambient temperature, silver oxide films were created using an oxygen partial pressure of 2x10-6 mbar and a sputter pressure of 4 Pascal.. From the knowledge of the deposition time, we have estimated the thickness of Silver Oxide films.

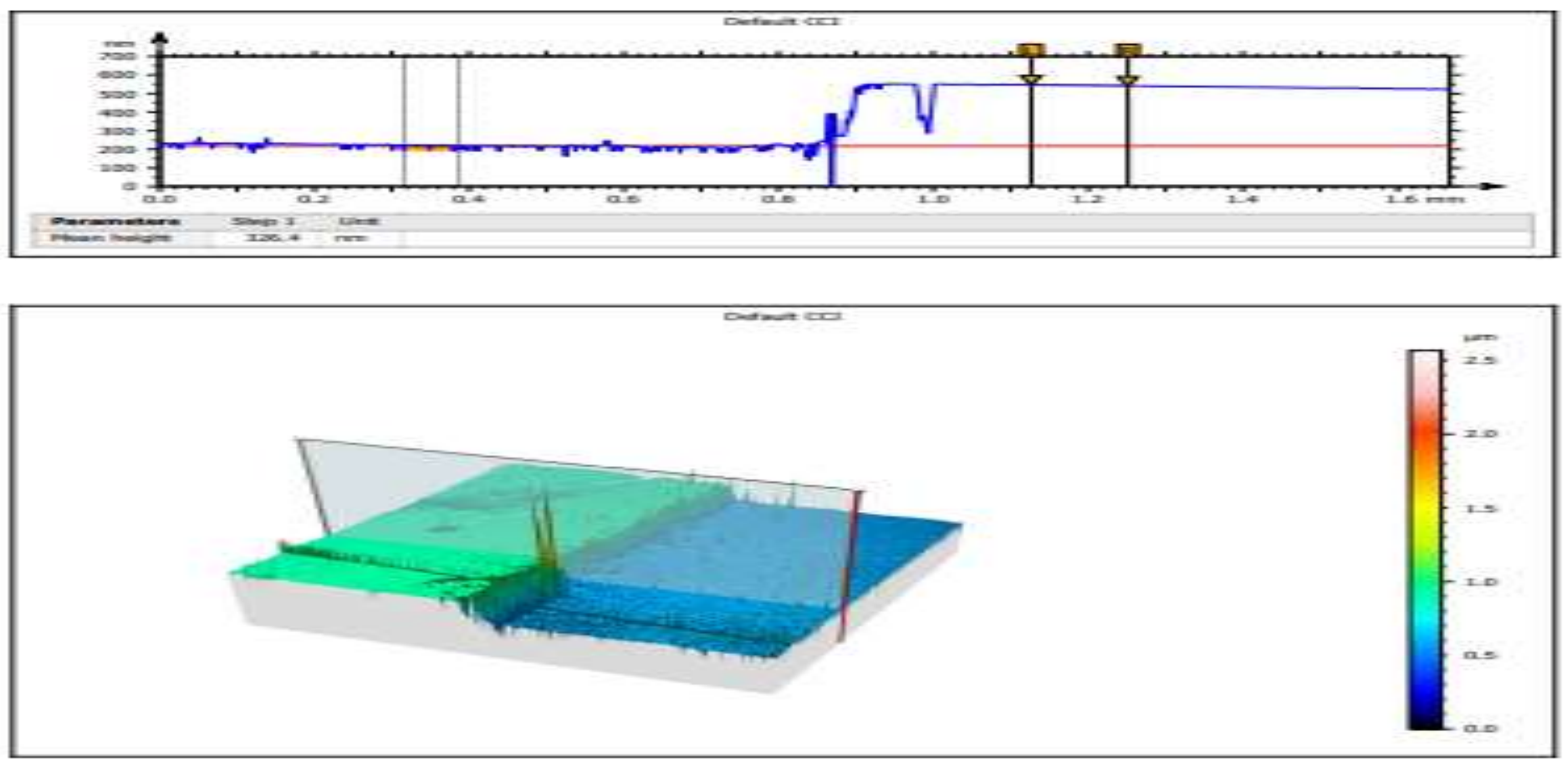

Fig.1a Non contact optical profiler of Ag_2O film thickness of 326 nm

Results

Band gap: Figure 3. shows , according to the equation (2) in order to estimate the binding energy at different film thicknesses, we have drawn $(ah\nu)^2$ versus hν graph for the film thicknesses of 72 nm. Then the tangents have been drawn of this curve and make intercept on hν axis gives 2.51 eV as binding gap energy .The value of band gap thus obtained is in close agreement with those obtained by others [3].

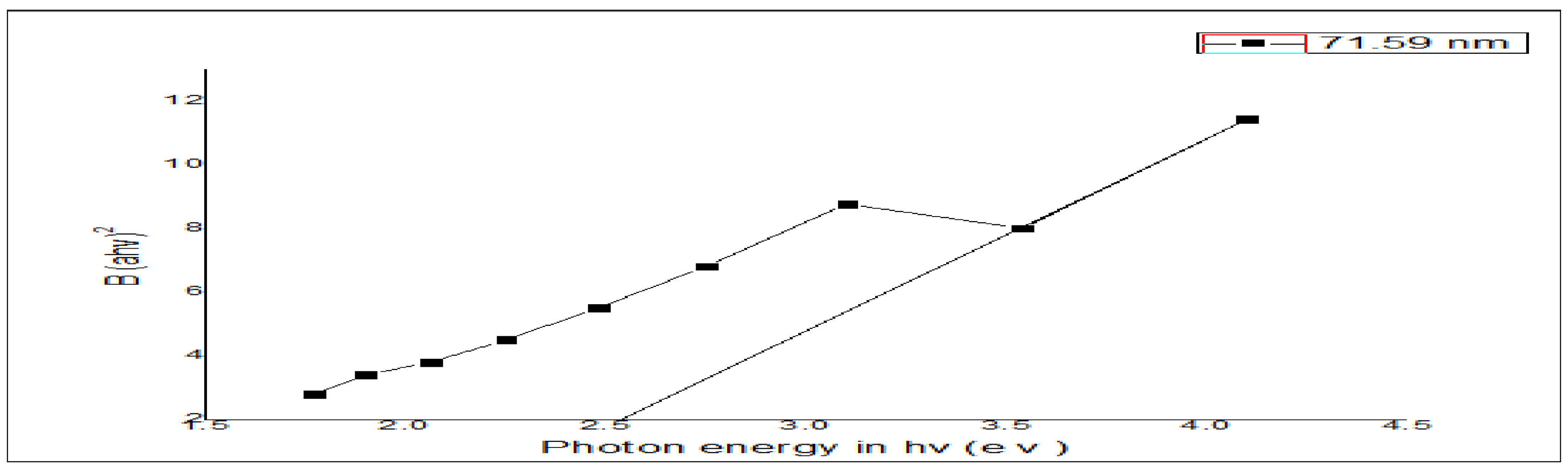

Fig. 7 indicates electrical resistivity versus thickness of Silver Oxide thin films, to determine the resistivity or resistance , we have made use of Vander Pauw technique (Four probe) using equation 1. For lower thickness the electrical resistivity remains always constant but after 200 nm, as film thickness increases the resistivity also increases similar type of behavior has been noticed in Ag/TiO_2 multilayer films [4] .

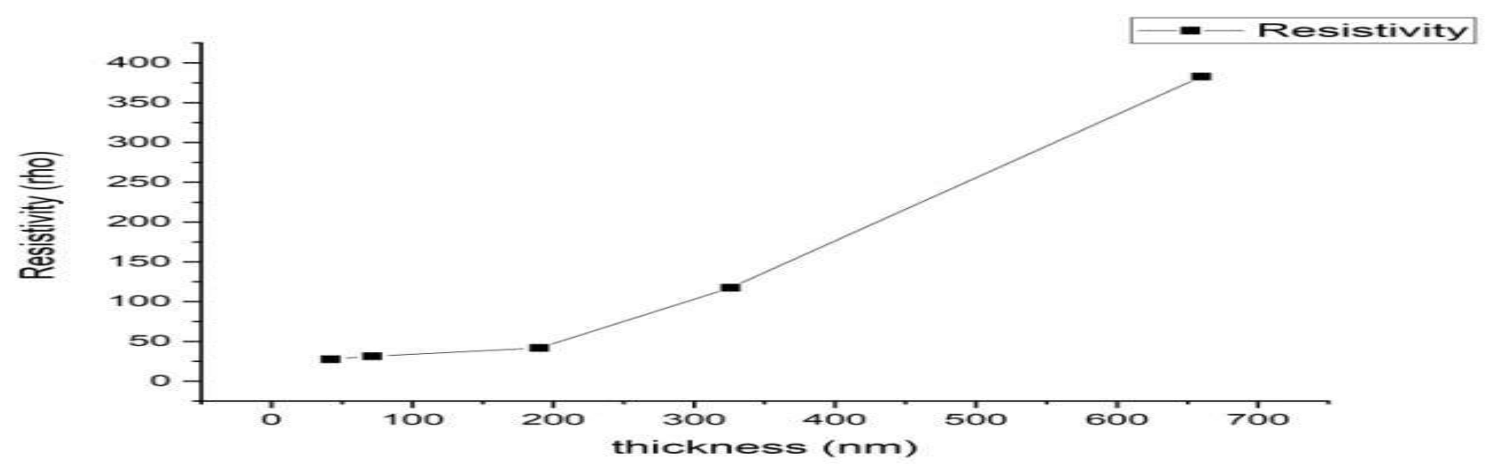

Fig. 7 Electrical resistivity versus Thickness of Silver Oxide thin films

In order to show the stoichiometry of the prepared Ag_2O thin film electrode, X-ray diffraction was used. The crystalline and cubic structure of the Ag_2O is revealed by the XRD peaks with centers at 26.27, 34.71, 38.36, and 51.89 Bragg's angles, as illustrated in Figure 4. Furthermore, it is noted that the crystal structure supports BCC and FCC when seen from the Braggs angle.

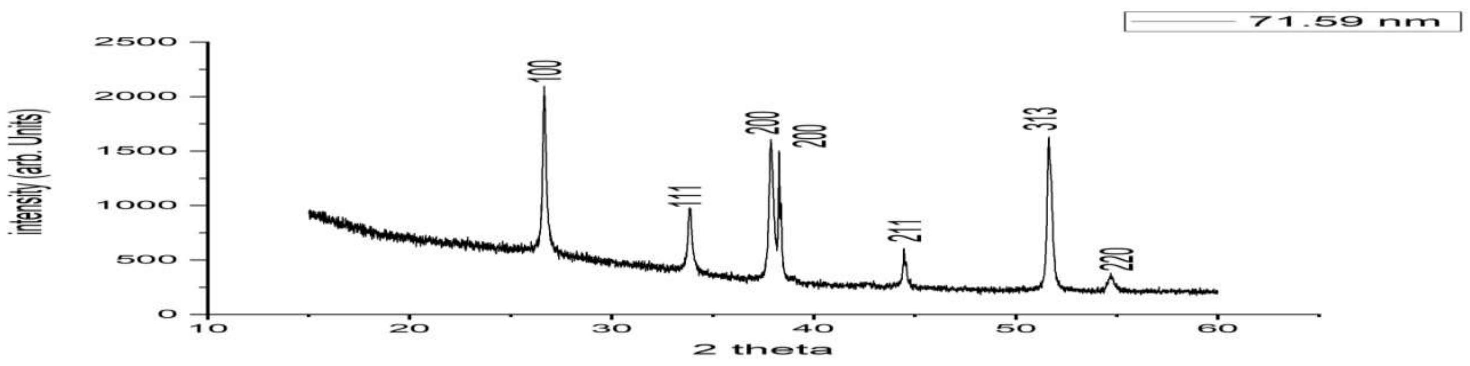

Figure 4. XRD analysis of 326 nm thickness

Conclusions

The Ag_2O thin films were successfully grown on FTO glass and annealed at 200 °C by using the RF sputtering technique. The deposition process has been done in 5 stages with different times of deposition .
Using a non-contact optical Profilometer we have determine d the thickness of the films .
The direct band gap energy calculated from the absorption data is 2.2 eυ.
As thickness increases the resistance also increases in the case of Ag_2O films.
The XRD studies clearly indicating that Ag_2O films have a crystalinity in nature.

References

1. GV AR, Kumar KN, Shaik H, Jafri RI, Naik R, Doreswamy BH. Optical and Electrochromic Properties of CeO2/WO3 Hybrid Thin Films Prepared by Hydrothermal and Sputtering. International Journal of Engineering Trends and Technology. 2022:1-8. https://doi.org/10.14445/22315381/IJETT-V70I5P201
2. Li B, Gao X. Room temperature-deposited silver oxide (AgxO) films by dc magnetron sputtering with high sputtering power density: impact of flow rate ratio of O2 to Ar gases on microstructure pattern, optical and electrical behaviors. Physica Scripta. 2021 Nov 2; 96(12):125848. **DOI** 10.1088/1402-4896/ac30a6.
3. Fakhri MA, Abdulwahhab AW, Dawood M, Sabah AI. Nano silver oxide based on insulator for optoelectronic device. InAIP Conference Proceedings 2020 Mar 25 (Vol. 2213, No. 1). AIP Publishing. https://doi.org/10.1063/5.0000182
4. Kim JH, Lee HK, Na JY, Kim SK, Yoo YZ, Seong TY. Dependence of optical and electrical 745properties on Ag thickness in TiO2/Ag/TiO2 multilayer films for photovoltaic devices. Ceramics International. 2015 Jul 1; 41(6):8059-63.

3rd International Conference on
Recent Trends in Materials Science & Devices
(ICRTMD 2025) 24-26 March 2025

Hybrid Conference
Venue: JVMGRR College, Charkhi Dadri (Haryana) India