Structural, Optical and Electrical Properties of Tin Oxide Thin Films for Application as a Wide Band Gap Semiconductor

Riti Sethi, Shabir Ahmad, Anver Aziz and Azher Majid Siddiqui*

Department of Physics, Jamia Millia Islamia, New Delhi-110025

*Corresponding author: amsiddiqui@jmi.ac.in

Abstract. Tin oxide (SnO) thin films were synthesized using thermal evaporation technique. Ultra pure metallic tin was deposited on glass substrates using thermal evaporator under high vacuum. The thickness of the tin deposited films was kept at 100nm. Subsequently, the as-deposited tin films were annealed under oxygen environment for a period of 3hrs to obtain tin oxide films. To analyse the suitability of the synthesized tin oxide films as a wide band gap semiconductor, various properties were studied. Structural parameters were studied using XRD and SEM-EDX. The optical properties were studied using UV-Vis Spectrophotometry and the electrical parameters were calculated using the Hall-setup. XRD and SEM confirmed the formation of SnO phase. Uniform texture of the film can be seen through the SEM images. Presence of traces of unoxidised Sn has also been confirmed through the XRD spectra. The band gap calculated was around 3.6eV and the optical transparency around 50%. The higher value of band gap and lower value of optical transparency can be attributed to the presence of unoxidised Sn. The values of resistivity and mobility as measured by the Hall setup were 78Ωcm and 2.92cm^2/Vs respectively. The reasonable optical and electrical parameters make SnO a suitable candidate for optoelectronic and electronic device applications.

INTRODUCTION

There exist two main oxides of tin: stannic oxide (SnO_2) and stannous oxide (SnO).The existence of these two oxides is attributed to the dual valency of tin with the oxidation states of +2 and +4. Both of these oxides are known to be wide band gap semiconductors with tetragonal rutile and litharge type structures respectively [1]. Of these, SnO_2 has been widely characterized and explored in many applications such as solid state gas sensors, solar cells, transparent electrodes and other optoelectronic devices [1]. On the other hand, very little is known about SnO, for example, its electronic band gap is not accurately known but it lies somewhere in the range of 2.5 to 3.4eV [2, 3, 4]. The possible reason behind the lack of literature on SnO might be the fact that no single crystals of SnO are available that may facilitate more detailed studies of stannous oxide. However, this does not imply that stannous oxide does not possess any technological importance. In the past decades, SnO has been used as a key anode material [5], coating substance [6], catalyst [7] and precursor for the production of SnO_2 [8] because of its properties of gas-sensitivity and metastability to transform in SnO_2 at O_2 rich ambient. SnO is a p-type semiconducting material and a better one than its counterparts such as ZnO, NiO, Cu_2O etc because of Sn 5s nature at the valence band maxima (VBM), which results in a more effective hole-transport path and higher hole mobility. Previous studies have shown that the maximum hole mobility of SnO films is about 2.6cm^{2}V^{-1}s^{-1} [9] which is fairly high among p-type conductive oxides and can be further improved through doping. These properties put SnO as a promising candidate for p-type semiconductor material which can be utilized for novel optoelectronic and electronic devices.

Device based application requires the control of chemical composition and microstructure which then determines the optical and electrical properties of the film. Even though in this work we have been able to obtain epitaxial SnO film but the problem of narrow growth window confine its commercial applications. Therefore, it becomes very

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