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Characterization and optimization of SnO_2(Sb_2O_3, 5wt% doping) : O_2 films by DC-magnetron sputtering from a metallic tin target

I. Lee : *Sungkyunkwan University*

K. J. Park : *Agency for Technology and Standards*

S.H. Shin : *Agency for Technology and Standards*

J. H. Shin : *Agency for Technology and Standards*

J. H. Lee : *Agency for Technology and Standards*

J. S. Yi : *Sungkyunkwan University*

1. Introduction

We have carried out an investigation on double-layer back-reflection coating using SnO_2 for thin film solar cell. Tin oxide films are of great interest owing to their practical application in technology. Considerable attention has been devoted to the study of physical and chemical properties of tin oxide films[1-2], with applications as conductive electrodes in thin film solar cells, electronic devices and flat panel displays. However, very few papers related to SnO_2 thin films obtained by reactive sputtering from a metallic target have been published and little is known about the relationship between the processing conditions and film properties in the SnO_2 deposition.

2. Experiment

These experiments were carried out in a dc-magnetron sputtering system, using a L560 DC power Supply, DC Plasma Products, Inc., GER. The sputtering target was a 1.990inch diameter, 99.9%purity, tin metallic supplied by Cerac. Inc., The substrates employed were Corning glass, degreased ultrasonically in a dilute detergent solution, rinsed ultrasonically in deionized water and blown dry in N_2 gas before they were introduced into the chamber. Antimony-doped tin oxide films(SnO_2-Sb_2O_3 : 95-5wt%) on glass substrates have been prepared by reactive magnetron DC-sputtering in Ar-O_2 plasma from a metallic target. We fixed RF input power of 25W and changed a substrate temperature from room temperature to 250℃. The Ar/O2 gas ratio were varied from 10/0 to 6/4 while keeping a total pressure as 20sccm. The film thickness was measured using a step manufactured by a α-step system. Crystallographic properties were characterized by using an X-ray diffraction(XRD) scan angle was ranged from 20 to 70 degree with a speed of 1-degree/min.

Resistivity and Resistance were measured by a 4-point probe system of CMT SR-1000.

3. Resert

We studied the electrical and optical properties of the SnO_2 films. The XRD indicate that the (101) planes diminishes rapidly with increasing oxygen gas concentration and disappears almost completely at 10% oxygen. With increasing oxygen concentration, the (101) planes starts appearing and becomes very strong at 5% oxygen level. At 15% oxygen, this (101) planes disappears and instead (110) and (200) diffraction planes start appearing. The results show that crystalline films has cassiterite-like diffraction patterns with preferred orientation in the (110) planes. Well-defined (110), (101), and (211) cassiterite peaks were obtained at these conditions. The crystallinity of the films is improved when the discharge voltage and oxygen content increase. A very high growth rate of nearly 7Å/s was realized in this process with good homogeneity, high transparency, and low resistivity. A film of 900Å thickness exhibited the lowest electrical resisitivity, of 5×10^{-3} Ωcm, a mobility value of $5cm^2V^{-1}s^{-1}$, and a donor concentration of $2.5 \times 10^{20}cm^{-3}$. Films of 900-1000Å thickness having an average transmittance of nearly ~ 85% in wavelength range from 200nm to 880nm were used as transparent conducting oxide film substrate to fabricate back-reflector of thin film solar cells.

4. Reference

[1] C.G. Borman, R.G. Gordon, J. Electrochem. Soc. 136 (1989) 3820

[2] C.F. Wan, R.D. McGrath, S.N. Frank, J. Electrochem. Soc **136** (1989) 1459