ABSTRACT

Transparent Conducting Oxide (TCO) film/Silicon based solar cells are increasingly studied as prospective alternative to the costly single crystal p-n junction silicon solar cells. TCO films transmit the solar light directly into the active region of a solar cell with little attenuation. They can serve as a protecting layer, as a low resistance current collecting top contact of solar cells and can act as an anti-reflection layer. Porous silicon (PS) has many unique and advantageous properties for photovoltaic applications as well as manufacturing simplicity. A detailed study has been made to develop undoped and doped tin oxide (TCO) thin films through spin coating technique and their material properties are characterized. Solar cells with TCO/Porous silicon (PSi)/Silicon junctions are formed, junction properties are studied and presented.

Chapter 1 provides an introduction about the salient features of TCO and porous silicon. The aims of the present work are given. The second chapter provides the literature about the preparation techniques used, various properties reported and the intriguing crystal properties of SnO$_2$, SnO$_2$: F, SnO$_2$: Sb and PS are summed up. Chapter 3, gives an account of the various characterization techniques engaged in the present work for materials analysis. The design aspects of a simple and novel PC/microcontroller interfaced spin coating unit has been given in chapter 4. This instrument consists of the following hardware: a flat high speed turntable, a high speed motor and a substrate holder. The hardware associated with the high speed turntable are: (1) a Power supply, (ii) a Personnel computer (PC), (iii) a Microcontroller 8051 unit, (iv) a DC chopper and (v) a DC motor unit. The instrument can be run through a PC with a separate program written in visual basic to feed inputs for the turntable and its spin rate can be reached to a maximum of 6000 RPM. The optimization steps to prepare tin oxide (SnO$_2$, TO) thin films using the sol-gel spin coating technique are presented in chapter 5. The spin rate (co) and rotation time (t) have been optimized and film
thickness is found to be inversely proportional to $1/\omega$ and $1/\sqrt{t}$, agreeing with the theoretical models for coatings development by spin coating technique. The other process parameters like number of coatings, heating temperature and duration are varied to get low resistive Sn$_2$O$_2$ films and the materials properties are presented.

In chapter 6, the optimum value of dopant concentration and heat treatment temperature have been found as 7.5 atomic % and 375°C respectively for Sn$_2$O$_2$: F films. The influence of Fluorine doping, thickness and temperature of heating on the formation of Sn$_2$O$_2$:F films with best optoelectronic and morphological properties and reported. Chapter 7 gives a detailed analysis on the impact of gelation time, concentration of Antimony, turntable speed on the preparation of monophase and crystalline Sn$_2$O$_2$:Sb films. The optimum resistivity, carrier concentration, optical nature with respect to preferred orientation and morphology of the Sn$_2$O$_2$:Sb films are presented.

In chapter 8, the various electrochemical stages of porous silicon formation are given in detail. Photoluminescence properties are studies in relation to the structural and morphology of PSi layers. Raman and FTIR results are discussed elaborately to elucidate their chemical properties and porous nature to obtain maximum photoluminescence in the light of Quantum Confinement Effect (QCE).

Sn$_2$/PSi/p-Si/Al, Sn$_2$:F/PSi/p-Si/Al, and Sn$_2$: Sb/PSi/p-Si/Al heterojunction solar cells have been fabricated and detailed studies on the junction behaviour of the cells under dark and illumination have been carried out in chapter 9. The junction with Sn$_2$:Sb/PSi/p-Si/Al solar cell configuration has been found to have good rectifying properties. The junction properties have been studied and the solar light conversion efficiency are found to vary in the range of 2.6 to 6.6%. The observed open circuit voltage is about 450-520 mV and the short circuit current density variation is about 12-22 mA/cm$^2$. The possible junction interface mechanisms for such solar cell out-put are proposed. Chapter 10 provides the conclusion of the present study and the suggestion for future studies.