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Title of the thesis: Ion Beam Irradiation on Indium Oxide and Tin Dioxide Thin Films for Application in the Field of Gas Sensors

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Abstract

The thesis entitled "Ion Beam Irradiation on Indium Oxide and Tin Dioxide Thin Films for Application in the Field of Gas Sensors" is divided into six chapters. The highlights of each chapter are presented below.

Chapter 1 gives a brief account on transparent conducting oxides, explaining in the detail the properties, available synthesis methods and applications of indium oxide and tin oxide. The application of indium oxide and tin oxide as a gas sensor has been elaborately discussed with detailed description of the sensing mechanism, factors influencing the sensor performance and methods to improve the performance of indium oxide and tin oxide based sensors. Along with this, the interaction of energetic ion beams with solids has been elucidated with focus on the effect of energetic ion beams on the properties of indium oxide and tin oxide thin films and their effect on the gas sensing behavior.

Chapter 2 discusses the synthesis techniques, characterization tools and irradiation facilities utilized for this work. In the present work, we have employed thermal evaporation and thermal oxidation to synthesize indium oxide and tin oxide films, the details of which have been discussed in this chapter. The characterization techniques include X-ray Diffraction, Scanning Electron Microscopy, Rutherford Backscattering Spectroscopy, Atomic Force Microscopy, UV-Vis Spectroscopy and Gas-Sensing measurements. All these techniques along with the parameters of measurements have been discussed in this chapter. The details of low energy ion implanter and the Pelletron accelerator at IUAC, Delhi that have been used for irradiation measurements have also been described along with the details of the irradiation experiments performed.

Chapter 3 discusses the effects of 100 MeV Ag^{9+} and O^{7+} ions irradiation on the structural, optical and hydrogen sensing properties of tin oxide thin films. Ag^{9+} ions have a very large value of electronic stopping power (Se) in comparison to the O^{7+} ions [S_e(Ag) = 21.89 keV/nm and

$S_e(O)$ = 1.52 keV/nm]. The nature of defects produced in a solid material is greatly affected by the value of S_e, the energy and fluence of ion beam. Since, in our case the energy and fluence of irradiation of both the ion beams (Ag and O) have been kept constant, therefore, the value of Se plays a major role in determining the type of defects produced in the tin oxide films upon irradiation and the resultant modifications in the structural, morphological, optical and gas sensing properties. Also, to explain the formation of defects in tin oxide films as a result of irradiation, Thermal Spike model and its different approaches have been employed. Sensing characteristics were observed by measuring current as a function of time on exposure to different concentrations of hydrogen gas at an operating temperature of 300^{o}C.

Chapter 4 elucidates the effects of 100 MeV Ag^{9+} and O^{7+} ions irradiation on the structural, optical and methane sensing properties of indium oxide thin films. In this chapter also, we have discussed the effect of difference in the values of S_e of Ag^{9+} and O^{7+} ions on the properties of indium oxide thin films post-irradiation. The response characteristics of the pristine and irradiated films towards 100 ppm methane gas were studied at an operating temperature of 300^{o}C

Chapter 5 is devoted to the study of structural, optical and morphological properties
of indium oxide thin films implanted with 25 keV N+ and Co- ions. The modifications induced have been studied using Rutherford Backscattering spectrometry, X-ray Diffraction, Scanning Electron Microscopy, Atomic Force Microscopy and UV-Vis Spectroscopy. SRIM calculations
and simulations have been performed to determine the projected range and energy loss of nitrogen and cobalt ions in indium oxide and tin dioxide thin films. These calculations give an idea about the ion-matter interactions which help in explaining the resultant modifications in the structural, microstructural and morphological properties..

Chapter 6 lists the conclusions and summary of the work along with a brief insight
into the future prospects of the work.