PREFACE

Methane is an important gas to be utilized as fuel for domestic and industrial purpose in the form of CNG. The other properties of methane such as flammability make it very dangerous for labors working in the coal mines. It is explosive, if concentration rises in the ranges of 5 % to 15 % (Lower and Upper explosive limit). Near about 5 % presence of methane in air, it is asphyxiated in atmosphere. So, superior sensitivity and detection of methane is required. That is why it is essential to develop or fabricate a reliable and relatively inexpensive solid state based sensor for detection of methane. Earlier literatures reports show that the metal oxides have been proven to be potential candidates for the development of gas sensors. This thesis work is aimed to enhance the sensitivity of ZnO based thin films for methane sensors by doping of novel transition metal-ions such as Fe, Cu, Co and Ni in the ZnO. The doping affected the thin films formation in turn having unique nano-structures such as Nano-Wrinkled, Nano-Crystalline, Nano-Wired, Nano-Strips and Nano-Net were achieved. These nano-structured based thin films sensor show the detection of 100 – 500 ppm methane between the operating temperatures range of 75 ^{o}C – 200 ^{o}C. Sensing study and fabrication of thin film sensors are explained in this thesis by chapter wise. The performance of doped ZnO based sensors are better than undoped thin films due to increased adsorption sites at the surfaces by dopant ions as suggested by the sensing mechanism theory.

Brief descriptions of the research work presented in the thesis are divided into nine chapters and have been discussed as follows:

Chapter I contains a general introduction of the needs of gas sensor and availability of methane sensors and its specifications. The review of the semiconductor based gas sensors and brief explanation of the properties of Zinc oxide, properties of glass substrate, mechanism of sensing, effects of electrical properties, porosity, and moisture on gas sensor and, also role of nano-structure in the sensing. It also contains descriptions of deposition techniques of thin film such as drop, dip, spray, spin coating and sputtering. Characterization techniques and instruments / equipments used in study of characterizations of thin films are also described in this chapter. Explains about the substrate preparation, brief description of sensing set up and that was assembled in lab and experimental procedure utilized for sensing or testing of gas.

Chapter II Contains the fabrication of undoped ZnO flat thin film and up to 8 % Fe, Cu, Co, Ni doped ZnO thin films, undoped ZnO Nano-Wired, up to 8 % Cu doped ZnO Nano-Strips and up to 8 % Fe doped ZnO Nano-Net based thin films. These films are fabricated by chemical route and dissolving the chemical in aqa regia solution and using high rpm spin technique depositions. These nano-structured thin films characterization by XRD, SEM, EDX and AFM, while HR-SEM utilized in the analysis of surface for nano-wrinkled and nano-strips based thin films.

Chapter III application of thin film in methane sensing, for 100 – 500 ppm concentration of methane between the operating temperatures range of 75 – 200 ^{o}C is described in details in this chapter.

Chapter IV the sensing study as application of thin film in methane sensing, for 100 – 500 ppm concentration of methane between the operating temperatures range of 75 – 200 ^{o}C is

also described in this chapter. Selectivity study of sensor in presence of hydrogen is also described here.

Chapter V results suggested that the response of sensor is better than other developed films. Selectivity in the presence of hydrogen is also quick for fast performances in methane sensing.

Chapter VI the sensing study and results suggested that the response of sensor is better than other films such as undoped ZnO flat thin film.

Chapter VII the sensing study and results suggested that the response of sensors better than undoped ZnO flat thin film.

Chapter VIII study of methane sensing in the 100 – 500 ppm concentration range between the operating temperature range 100 – 200 ^{o}C suggested that the response of sensors are better in the ascending order as undoped ZnO nano-wired, 8 % doped Fe ZnO Nano-Net, 8 % Cu doped ZnO Nano-Strips respectively. In Sensors, selectivity in presence of hydrogen better are better for Cu doped ZnO Nano-Strips based thin film sensor.

Chapter IX described the summary of present research work and its future scope associated future work in the field of methane sensing.