PREFACE

The scope of this thesis work is aimed to understand the growth and characterization of vertically aligned ZnO nanorods by the radio frequency (RF) magnetron sputtering. The structural, morphological, optical and magnetic properties of ZnO nanorods have been investigated by means of X-ray diffraction, field emission scanning electron microscopy, temperature dependent photoluminescence spectroscopy, micro-Raman scattering and vibrating sample magnetometer respectively. Further, the grown ZnO nanostructures have also been subjected to investigate the ammonia gas sensing property as a function of temperature and various concentration of gas. In addition, the photocatalytic behavior and photostability of ZnO nanorods as a catalyst to degrade organic pollutants under the irradiation of visible light have been demonstrated. The thesis consists of 7 chapters including introduction and conclusion.

In chapter 1, the importance of ZnO and the growth of ZnO nanostructures by various deposition techniques particularly using the RF magnetron sputtering have been reviewed. The importance of 1-D nanostructures (nanowires and nanorods) and its growth mechanism has also been briefly reviewed.

The experimental techniques employed in the present thesis work have been discussed in chapter 2 which includes the fabrication of ZnO nanorods by the RF magnetron sputtering at elevated temperatures. Field emission scanning electron microscope equipped with energy dispersive X-ray spectrometer, X-ray diffraction, temperature dependent photoluminescence spectroscopy, micro-Raman scattering, vibrating sample magnetometer, resistance based gas sensor setup and photocatalytic study were briefly discussed.

Chapter 3 deals with the fabrication and characterization of ZnO nanostructures on silicon (111) substrates. The evolution of 1-D ZnO nanostructures has apparently been investigated by varying the growth parameters such as argon and oxygen pressure, growth duration and substrate temperature. The migration length of the nanostructures varies according to the deposition pressure and temperature which alter the diameter, length and morphology of the nanostructures. The optical properties of the ZnO nanorods have been extensively investigated by micro-Raman scattering and temperature dependent photoluminescence studies. The concentration and nature of point defects vary with the composition and ambient of the gases present in the chamber. The blue shift of the A_1(LO) Raman phonon mode from its standard value is attributed to the enhancement of free carrier concentration due to the presence of more intrinsic point defects in the nanostructures.

The growth and characterization of indium doped ZnO nanorods have been described in chapter 4. Indium doped zinc oxide nanorods are homogeneously distributed on the substrate with the preferential orientation along the (002) crystallographic plane. The indium atoms are found to be spatially incorporated into the ZnO lattice along the axial direction by the migration of adatoms from the ITO coated glass substrate at the growth temperature of 550 °C. The doping concentration and mobility of the indium doped zinc oxide nanorods are determined by the Raman line shape analysis of the longitudinal optical phonon–plasmon coupled mode.

Chapter 5 describes the enhancement of the crystalline and optical qualities of ZnO nanorods by the post growth annealing under oxygen and vacuum atmospheres. The temperature dependent zero-field cooled and field cooled magnetizations reveal the coexistence of antiferromagnetism and ferromagnetism below 7 K. However, the ferromagnetism is dominant and stable between 7 K and room temperature. The decrease of ferromagnetism in ZnO nanorods is directly associated with the compensation of point defects such as zinc vacancy, zinc interstitial sites and oxygen vacancy as substantiated by the radiative transition between shallow donor and acceptor energy levels. These results confirm that the point defects play an important role in enhancing the room temperature ferromagnetism in ZnO nanorods.

Chapter 6 has focused on the applications perspective of ZnO nanorods. The gas sensing and photocatalytic dye degradation properties of ZnO nanorods have been investigated. The results show that the ZnO nanorods are highly sensitive to ammonia and the concentration level as low as 25 ppm can be effectively sniffed using the resistance based sensing device. Visible light driven photocatalytic behavior of ZnO nanorods has also been demonstrated using three different types of dyes namely Methylene Blue, Rhodamine B and Methyl Orange. ZnO nanorods reveal the high degradation percentage for methylene blue under visible light. The substrate level ZnO nanorods exhibit suppressed photocorrosion and high photostability as evidenced from the recovery and recycling studies.

The conclusion derived from the current studies and the future outlook of the thesis is presented in the chapter 7.

CONTENTS

LIST OF PUBLICATIONS

1. **P. Sundara Venkatesh**, V. Ramakrishnan and K. Jeganathan, Vertically aligned indium doped zinc oxide nanorods for the application of nanostructured anodes by radio frequency magnetron sputtering, ***CrystEngComm***, **2012**, 14, 3907-3914.

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3. M. Gopalakrishnan, V. Purushothaman, **P. Sundara Venkatesh**, V. Ramakrishnan and K. Jeganathan, Structural and optical properties of GaN and InGaN nanoparticles by Chemical Co-precipitation method, ***Mater Res Bull.,*** **2012**, 47, 3323-3329.

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5. **P. Sundara Venkatesh**, V. Ramakrishnan and K. Jeganathan, Investigations on the growth and optical properties of one dimensional ZnO nanostructures grown by radio frequency magnetron sputter deposition, ***Mater Res Bull.,*** **2013**, 48, 3811-3816.

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9. **P. Sundara Venkatesh**, S. Balakumar and K. Jeganathan, Post annealing effects on the structural and optical properties of vertically aligned undoped ZnO nanorods grown by radio frequency magnetron sputtering, ***RSC Advances*** **(DOI: 10.1039/C3RA43639J).**

10. **P. Sundara Venkatesh**, P. Dharmaraj, V. Purushothaman, V. Ramakrishnan and K. Jeganathan, Point defects driven enhancement of NH_3 gas sensing properties in ZnO nanostructures **(Submitted)**.

11. **P. Sundara Venkatesh**, S. Prabhu, K. Jothivenkatachalam and K. Jeganathan, Dye excitation and surface defects mediated photocatalytic behavior of vertically aligned undoped zinc oxide nanorods grown on silicon substrates **(Submitted)**.

12. V. Purushothaman, **P. Sundara Venkatesh**, R. Navamathavan and K. Jeganathan, Direct comparison on the structural and optical properties of self-catalytic and catalytic assisted gallium nitride (GaN) nanowires by chemical vapour deposition **(Submitted)**.