SYNTHESIS AND CHARACTERIZATION OF METAL OXIDE NANOPARTICLES AND NANOSTRUCTURED FILMS FOR DYE-SENSITIZED SOLAR CELL APPLICATIONS

by

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Centre for Energy Studies

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to the

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Dedicated to

My Parents….

Certificate

This is to certify that the thesis entitled **"Synthesis & characterization of metal oxide nanoparticles and nanostructured films for dye-sensitized solar cell applications"** being submitted by **Ms. Charu Dwivedi** to the Indian Institute of Technology Delhi, for the award of the degree of ***'Doctor of Philosophy'*** in Centre for Energy Studies, is a record of bonafide research work carried out by her. **Ms. Charu Dwivedi** has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard. The results contained in this work have not been submitted in part or full, to any other University or Institute for the award of any degree.

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Abstract

The growth of various nanostructures of ZnO (nanorods, nanoflowers, etc.) and hollow microspheres of TiO_2 by continuous spray pyrolysis (CoSP) rector has been studied. The ZnO nanostructured films are used as a photoelectrode in dye-sensitized solar cells (DSSCs) and their performance is investigated. The thesis begins with an introductory chapter on various photovoltaic technologies and the integration of nanotechnology in PV especially in dye-sensitized solar cells. The operating principle of DSSC is presented. The current status of this technology in India has also been discussed. Second chapter introduces the various experimental and characterization techniques that have been used for the synthesis of metal oxide nanoparticles and nanostructures. The main thesis work involves five distinct studies. Firstly, the conditions to synthesize ZnO nanoparticles via CoSP reactor and the effect of high DC voltage (1kV) applied during synthesis are studied. The as-synthesized nanoparticles are then utilized to prepare thin films on glass substrate or Indium Tin Oxide (ITO) coated glass substrates via spin coating. The films grown by spin coating have issues with the adhesion property. So, it is thought of growing films directly by keeping the substrates inside the CoSP reactor, which saves time and helps in the collection of both nanoparticles and nanostructured films altogether. Thus secondly, the optimum conditions to grow nanorod and various other nanostructures on various

substrates (glass, ITO, Si, Cu, etc.) using a seed layer are studied. In this, the effect of substrate pre-treatment, deposition time, seed layer, annealing temperature, applied voltage have been studied. A comparative study of the PL properties of as collected nanoparticles and nanostructured films deposited at the same time is also done. Thirdly, the conditions to synthesis of aluminium doped ZnO (AZO) nanoparticles and nanostructured films are investigated. Further, the effect of seed layer and annealing temperature is studied on the morphology of nanostructured films. The current–voltage curves of the thin film with ZnO and AZO nanorod arrays are measured. Fourthly, the growth of hollow microspheres of TiO_2 and the effect of precursor concentration, applied voltage and annealing is also studied. The precursor concentration and applied voltage are found to have a direct impact on the size of the microspheres, which is also evident in the absorption spectrum. Finally, these as-synthesized nanostructures of ZnO are incorporated as a photoelectrode and the hollow microspheres of TiO_2 are incorporated as a scattering layer on top of a TiO_2 (~ 20 nm) transparent layer in DSSCs and their performance have been investigated. Effect of deposition time of ZnO nanorod array films as photoelectrode on cell efficiency is presented. The thesis concludes with a summary of the work done, some general conclusions and comments on possible future directions.

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