NANOROD STRUCTURES FOR ENERGY CONVERSION APPLICATIONS

By

Ranganath Teki

An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Major Subject: Chemical Engineering

The original of the complete thesis is on file
in the Rensselaer Polytechnic Institute Library

Examining Committee:

Prof. Nikhil Koratkar, Thesis Adviser
Prof. Toh-Ming Lu, Thesis Adviser
Prof. Steven Cramer, Member
Prof. Marc-Oliver Coppens, Member
Prof. Joel Plawsky, Member

Rensselaer Polytechnic Institute
Troy, New York

April 2009
(For Graduation May 2009)

ABSTRACT

The remarkable size-, surface-, and shape-dependence of physical, optical, and electronic properties of nanoscale materials make them compelling components of modern materials applications in a variety of fields. They are currently playing a key role in the development of alternate energy devices like fuel cells and solar cells as well as modern energy storage devices like lithium-ion batteries.

Oblique angle deposition (OAD) is a technique which allows for fabrication of unique nanostructures, which cannot be grown by advanced lithographic techniques. OAD is a physical vapor deposition technique in which flux arrives at a large oblique incidence angle from the substrate normal. It is simple, fast, cheap, has high mass production capability and can generate unique two- and thee-dimensional nanostructures with large aspect ratio and controllable porosity, shape and symmetry. The fact that these structures can be integrated onto a substrate platform makes them practical for many realistic applications.

We have tried to utilize nanorods grown by OAD in various key device applications of today's energy starved society. We first explained the enhanced photoemissive response of nanostructured topologies, which could result in the development of new photo-multiplier systems with dramatically improved performance. We optimized the growth of single crystalline ZnO nanorods and ITO nanorods by magnetron sputtering at low temperatures and explored their use as enhanced transparent conducting electrodes for polymeric photovoltaic cells. We studied various Pt nanorod based electrode architectures for proton exchange membrane fuel cells and showed that they give higher mass specific performance than conventional Pt-black electrodes. We demonstrated that nanostructured Si thin film based anodes are potentially better than conventional carbon based anodes and can lead to enhanced rechargeable Li-ion batteries with higher capacity.