INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

This thesis entitled "Hierarchical Metal Oxides for Photoelectrochemical Water Oxidation and Sensing Applications" outlined several aspects in design and development of metal oxide-based photoanode to improve the photoelectrochemical water splitting performance. ZnO and $BiVO_4$ have been used as model systems to fabricate photoanodes for photoelectrochemical water oxidation. Several efforts such as different morphology, heterojunction formation, and surface modifications with co-catalysts have been made to enhance the photoelectrochemical activity. This thesis follows the order: firstly, an overview of global energy consumption and future requirement, need for a sustainable energy source to produce zero-emission H_2, is given in **Chapter 1**. A brief literature survey on current scenario as well as challenges associated with the fabrication of photoanode is discussed. In the later section, a short introduction to metal oxide-based Chemiresistor sensor devices and performance parameters is also included.

Chapter 2 comprises a short discussion on different techniques used for the characterization of as-synthesized materials and fabricated photoanodes. A short description related to the development of Chemiresistor sensor device, basic architecture, and working principle for gas sensing is also included.

Chapter 3 outlined the idea of a ternary photoanode $BiVO_4$/GQDs/CoSn-LDH, in which CoSn-LDH act as surface active sites and GQDs as a conductive linker to extract holes from the $BiVO_4$ surface. $BiVO_4$ is an ideal candidate for photoanode material for solar driven photoelectrochemical water splitting, due to its proper band alignment, non-toxicity, and higher stability in alkaline and neutral pH. Cobalt based co-catalyst CoSn-LDH is prepared which shows the p-type conductivity to form a p-n heterojunction. GQDs, a conductive linker is integrated between $BiVO_4$ and CoSn-LDH as a bridged for better charge injections.

Chapter 4 describes the synthesis of Co(OH)F as a noble metal free redox mediator for boosted photoelectrochemical performance. Here, $BiVO_4$ is used as a model system and modified with Co(OH)F to improve the water oxidation kinetics. Cobalt based materials have long been recognized as promising co-catalysts for application in photoelectrochemical water splitting. Commonly used co-catalysts are Co-Pi, $Co(OH)_X$, Co_3O_4, and CoOOH. The catalytic activity of cobalt is enhanced after the incorporation of non-metal

elements, as they tend to reduce the thermodynamic and kinetic barrier. The conductivity, as well as the charge mobility, is improved due to the presence of Fluoride in $Co(OH)_x$, thereby improving the electro-catalytic activity.

Chapter 5 deals with the synthesis of hierarchical ZnO superstructures using biomass derived templating agent "Polygalacturonic Acid" directly over the FTO. Due to the anisotropic growth behavior and tunable electrical properties, ZnO nanostructures having dimensions such as 0-D, 1-D, 2-D, and 3-D are actively studied for their optoelectronic properties. We have utilized an anionic polysaccharide "Polygalacturonic Acid" for monitoring the hetero-epitaxial aggregated growth of ZnO building blocks. The non-classical growth mechanism is accounted as the origin of these superstructures, through the interaction between the polysaccharide and ZnO nanocrystal growth units.

Chapter 6 describes the synthesis of vertically aligned WO_3 nano-structures over FTO, which can minimize the Ohmic contact between semiconductor and collecting electrode, will aid smoother transport of charge carriers, thereby enhancing the sensitivity of the devices. Such an approach is critical, wherein ultrasensitive detections are needed at very low concentrations of analytes, which results in smaller current values in terms of detection.