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Synthesis of Metal Oxide Doped Photocell: A Review

V. N. NILKHAN, G. S. NAKHAT, R.V. BARDE

Department of Physics, GVISH, Amravati-444604, Maharashtra, India
***Corresponding Author E-Mail:** rajeshbarde1976@gmail.com

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Abstract

Photocell, it is solid state device that converts solar energy into electrical energy. In future, increasing energy demand will force us to seek for the environmentally friendly, clean alternative energy resources. Photo electrochemical cells have attracted more of interest because the solar energy which is unlimited source of energy can be used to produce the cost effective and environmentally friendly electric energy. There are wide applications of photocells which include industry, electronic applications, our day-to-day life and many more. Though photocell has wide range of applications it has to suffer by some challenges and limitations. The main challenge of photocell is their conversion efficiency (efficiency of conversion of light energy to electric energy). Conversion efficiency is important in order to get perfect photocell. In this paper, all these aspects of photocell are discussed.

Keywords: Photocell, Metal Oxide Photocell, Photoelectrochemical Cell, Solar Cell

Introduction:

The increasing energy demand in the near future will force us to seek for the environmentally friendly, clean alternative energy resources. Photo electrochemical cells have attracted more of interest because the unlimited sun-light source can be utilized to the cost effective and environmentally friendly electric energy. Photo electrochemical cells have been one of the promising candidates for conversion of sunlight to electric energy. The crystalline silicon solar cell has been widely used for solar to current conversion over the past decade. These devices are still too expensive to compete with conventional grid electricity [1].

Metal oxide material base PV cells have been studied intensively, as promising energy resources with the extraordinary advantages of low cost, environmentally friendly, easy fabrication and lightweight compatibility with large-scale flexible substrates. Nowadays, many researchers have been focused on increasing the applications of PV Cell. The metal oxide bases photocells have attracted a lot of attention, as their industrial and electronic properties can easily be improved with the unique combination of the oxide with metals. Metal oxide base photocells are widely explored in the day-to-day devices, especially photovoltaic applications. Photocell is a resistor that changes resistance depending on the amount of light incident on it [1, 2].

In 1883, The American inventor Charles Fritts created a working of photocell. Photocell is solid-state device that converts solar energy into electrical energy [2]. A device used to convert light energy into electrical energy is called Photo Electric Cell. Photocell is based on the phenomenon of Photoelectric effect. Photo cell are of three types.

i) Photo-Emissive Cell
ii) Photo-Voltaic Cell
iii) Photo-Conductive Cell

Photocells can be made up of different materials like polymers based photocells, metal oxide based photocells. In this context, we are going to study metal oxide based photocells. Here, photocells are synthesised from various metal oxides like tio_2, Fe_2O_3, Zno etc. Their different synthesis processes, techniques, experimentation, properties, efficiencies etc. is studied. There are different basically 3 steps to prepare photocell. These are 1) preparation of nanoparticle. There are several methods have been developed to produce metal nanoparticles. Two synthesis approaches have been identified that is top down and bottom up approach. But top down method does not have good control of particle size and structure [3,4]. And hence bottom up method is approach that is most used by scientist in synthesis of photocell. Then 2) Preparation of metal oxide thin films and 3) preparation of photocell. Then prepared photocell is analysed by different techniques like XRD, SEM, IPCS, TEM etc.

We have wide application range of photocell as per the increasing energy demand in the near future will force us to seek for the environmentally friendly, clean alternative energy resources. Photo electrochemical cells / photocell have attracted more of interest because the unlimited sun-light source can be utilized to produce the cost effective and environmentally friendly electric energy [1]. There are wide applications of photocells which include industry, electronic applications, our day-to-day life and many more. Though photocell has wide range of applications it has to suffer by some challenges and limitations. The main challenge of photocell is their conversion efficiency (efficiency of conversion of light energy to electric energy). Conversion efficiency is important in order to get perfect photocell [1-8].

In this context, we will discuss what is photocell, preparation of photocell, analyse the photocell, study characteristics of photocell and many more. In this paper, all these aspects of photocell are discussed.

Experimental:

There are different basically 3 steps to prepare photocell. These are 1) Preparation of nanoparticle. 2) Preparation of metal oxide thin films 3) Preparation of photocell.

Preparation of Nanoparticle

There are several methods have been developed to produce metal nanoparticles. Two synthesis approaches have been identified that is top down and bottom up approach. They are described as follows:

A) Top-down method: In top-down method bulk material has been reduced to nanomaterial. Top-down method comprises of milling, lithography and repeated quenching. This approach does not have good control of particle size and structure [9].

B) Bottom-up method: In case of bottom up method, the nanomaterial are synthesised from elementary level. Bottom up method is approach that is mostly used by scientists in synthesis of nanoparticle as it involves building up a material from bottom: atom by atom, molecule by molecule, and cluster by cluster. The different methods are used to produce nanomaterial are Sol-gel method, vapour seposition method, thermal deposition method etc [9].

C) Sol-gel method: sol-gel process is a method for producing solid materials from small molecules the method is used for fabrication of metal oxides, especially the oxides of silicon and titanium. The process involves conversion of monomers into colloidal solution (sol) that acts as the Pressure for an integrated network (gel) of either discrete particle or network polymers. Typical precursors are metal alkoxides.

Preparation of Metal Oxide Film:

There are different methods used in preparation of metal oxide films. ITO glass coated with metal oxide by squeegee method which is as follows:

Squeegee method: Metal oxide high compact thin film was coated on ITO glass (Indium-tin oxide coated glass, 8-12 ohm resistance) by squeegee method. The preparation by squeegee method is as follows: The powder of semiconducting materials (1gm) was mixed with concentrate nitric acid (0.1 ml) and distilled water (2 ml). Then the highly concentrated nano particles were added drop by drop on films. The nanoparticles were adsorbed on the surface of semiconductor due to the surface porosity and diffusion. After well mixing, 0.2 ml of Triton X-100 (Wako) was mixed to get a paste. The paste was then used to prepare the film by squeegee method on ITO glass. Finally, the film was heated at 350 °C for 1 h in an air environment [1].

Then, the coated film is loaded with nanoparticles by different depositing techniques.

Preparation of Photocell:

The counter electrode was prepared by a magnetron sputter method on an ITO glass. The semiconductor film was used as a working electrode in a solar cell whereas a Pt film coated ITO glass was used as a counter electrode. The two electrodes were sandwiched, and then the electrolyte solution was filled between these two electrodes [1]. The sample structure is given below:

Fig1. Sample structure of photocell

Properties of Photocell:

Some properties of different photocell are discussed below [1-12]

Table1: Properties of photocell

Property	**Crystalline silicon Photocell**	**Au-tio$_2$**	**Au-Fe2O$_3$**	**Au-Zno**	**DSSC**
Production cost	Expensive	Moderate	Moderate	Moderate	Low
Life time	More than Other photocell	Lower than Silicon	Lower than Silicon	than Silicon	Lower than Silicon
Efficiency	Higher than other photocell	More than Au-fe$_2$O$_3$ & Au-Zno	More than au-Zno	IPCE value= 15% At 500 nm	--

Characterisation of Material:

The UV-visible transmittance absorption spectra of thin-films were measured using a UV visible spectrophotometer [1]. The Field Emission Scanning Electron Microscope was used for the thin films imaging and analysing for film thickness and structures [1,5,14]. The thin films were characterized by X-ray diffraction (XRD) using an X-ray diffractometer [7, 11, 14, 17]. Current-voltage characteristics were measured using c I-V curve analyser. The current-voltage (I-V) characteristic under white light irradiation was done using a xenon lamp with an IR cut-off Filter. IPCE (incident photon to current conversion efficiency) values of the solar cells were measured using an IPCE analyser to estimate the quantum yield of the solar cells [1,6,15]. These techniques used for characterisation of photocell are describes below:

UV-VIS Spectroscopy: UV-VIS spectrometer uses visible light and ultraviolet light to analyse the chemical structure of substance. The transmittance absorption-peaks of nanoparticle deposited metal oxide thin films were determined by using UV-visible transmission spectrophotometer. All the thin films show the light absorbance in the visible region [1,5,6,7,8,10,15].

Scanning Electron Microscopy: A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample. We also recorded the FE-SEM images of the thin films and nanoparticles arrays. The nanoparticles were observed in films [1,5,6,14].

X-Ray Powder Diffraction (XRD): It is a rapid analytical technique primarily used for phase identification of a crystalline material and can provide information on unit cell dimensions. The analyzed material is finely ground, homogenized, and average bulk composition is determined. XRD spectrum of films, prepared by squeegee or any other method were also analysed by XRD. The spectrum was analyzed to the standard data sheet JCPDS and also standardization comparison with own XRD data [1, 5, 7, 8, 14, 17].

Transmission Electron Microscopy (TEM): Its main purpose is to create high magnification images of the internal structure of a sample. This can be used to gather information on crystalline structures, stress, internal fractures, contamination, and more [10, 14].

***IPCE (Incident Photon to Current Efficiency)*:** equipment used for measuring the action spectra or incident photon to current efficiency of solar cells with an active area $1cm^2$ [1,6,7, 17].

Characteristics of Photocell:

A typical circuit for measuring I-V characteristics is shown below. From this characteristics various parameters of photocell can be determined such as fill factor, efficiency etc. The rating of photocell depends on these parameters. The fill factor, more commonly known by its abbreviation “FF”, is a parameter which, in conjunction with Voc and Isc, determines the maximum power from photocell.

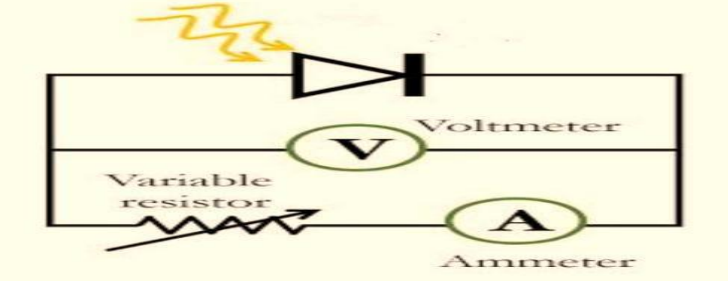

Fig.2: Circuit for I-V characteristics of photocell

The efficiency is the most commonly used parameter to compare the performance of one solar cell to another. Efficiency is defined as the ratio of energy output from the photocell cell to Input energy from the sun. In addition to reflecting the performance of the solar cell itself, the efficiency depends on the spectrum and intensity of the incident sunlight and the temperature of the solar cell [3].

Material Challenges:

There are wide applications of photocells which include industry, electronic applications, our day to day life and many more [5]. Though photocells have wide range of applications it has to suffer by some challenges and limitations. Challenges and limitations are stated below:

1) Efficiency are still challenge for scientists [1]. Efficiency are highly depends on quality of material and extremely sensitive to chemical and structural defeats.

2) Material availability was also seen to enter the equation in past decades as growth of production causes concern about long term sustainability technology.

3) Durability/life span also plays important in photocell. These are some of the challenges about photocell [1,3,7].

Conclusion:

This paper presents a recent development in study of photocell including synthesis methods, characterisation, properties, and applications. Photocell is one of the best ways to generate electrical energy by using solar energy to convert solar energy into electric energy. A lot of work has been done on synthesis of photocell and different techniques like XRD, SEM, TEM, UV-VIS etc. are used for characterisation. Conversion efficiency is important to get perfect photocell as well as other properties like low cost, availability of material. Life span of photocell is also important. Comparative study of different metal oxide based photo cell has been done in this paper. There are tremendous amount of application of photocell and we hope that this study of photocell will give us fascinating result which will be useful in different fields.

Conflict of Interest:

The authors declared that they have no conflict of interest.

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