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Investigations on Engineered Photovoltaic Materials

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Abstract

Significant developments of photovoltaic materials based on semiconductors are significantly reviewed and the advantages of thin film composites have been discussed in details. The main aim and brief outline of the present investigations carried out in this paper are here in concise form. The experimental facilities used throughout the whole work have been presented. This chapter also gives the strategy for advance research work in the field of Photovoltaic materials.
Keywords: *Solar Cells, Photovoltaic Materials, XRD, SEM, TEM.*

1. Introduction

Excluding fossil fuels, there are still several types of energy resources we could utilize in the earth, such as nuclear energy, wind energy and hydro energy. We choose solar energy as a replacement of other energy source we could utilize is because solar energy have several advantage over the others. Firstly, solar energy does not produce greenhouse gases as it produces electricity. A greenhouse gas can absorb radiation in the infrared range which is the basic reason of the greenhouse effect, the major cause leading to global warming at the present. Secondly, solar energy is effortlessly available on earth. Unlike wind enrgy and hydro energy, solar energy spread out equally in the world. Thus, the geographical site of a country is not likely to avoid the countries from taking benefit of solar energy. The world solar energy potential clearly specifies that the major part of the world could potentially consume the solar energy as the chief energy resources, particularly for nations close to the equator. Thirdly, the solar energy is infinite because large quantity of solar radiation accepted on the earth every day. The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000 exajoules per year. From data shown in Table 1, only 0.01% of the solar energy, if used, could provide enough energy for primary energy.

Table 1: Yearly Solar Flux and Human Energy Consumption

S.No	Resources	Energy Consumption
1	Solar	3,850,000 EJ
2	Wind	2,250 EJ
3	Biomass	3,000 EJ
4	Primary Energy	487 EJ
5	Electricity	56.7 EJ

Kim in 2006 showed that the short circuit current density and cell performance considerably increase as nanorods length amplifies because a higher quantity of the adsorbed dye on longer nanorods, resulting in improving alteration effectiveness [1]. Because Gratzel & Hagfeldt showed in 2000, titanium dioxide is abundant, low cost, and biocompatible and non-toxic [2], it is advantageous to be used in dye sensitized solar cells. Therefore, Mor et al [3], Pavasupree et al [4], Shen et al [5] and Suzuki et al [6] investigated nanotube and nanowire-structured TiO_2 photoelectrode for dye-sensitized solar cells.

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2. Materials and Methods:

The SnO_2 is synthesized in this way as shown in Fig.1

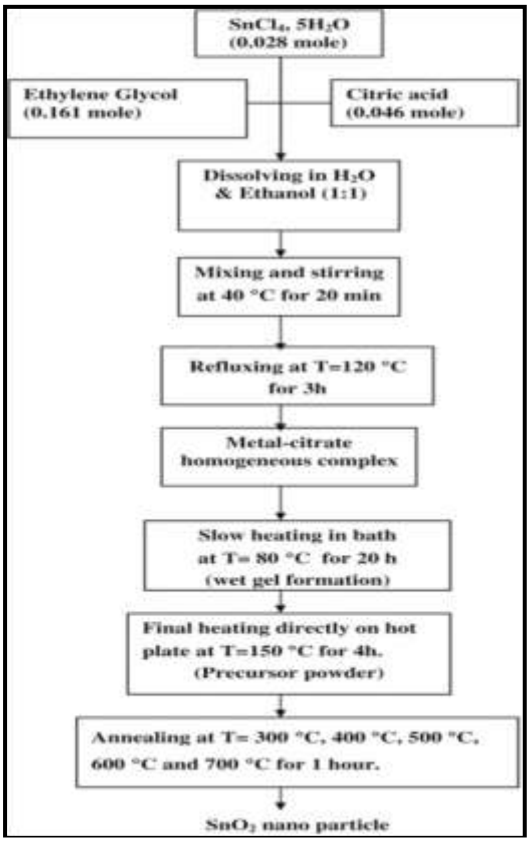

Fig. 1 Synthesis of SnO_2 particle

3. Fabrication Techniques for Thin Film

3.1 Spin Coating Unit

Spin coating is the most familiar techniques used for so many years for applying thin films to substrates and employed in a wide range of industries and technology areas [7]. A usual procedure consists of putting a small puddle of a liquid resin onto the heart of a substrate and then spinning the substrate at high pace as per requirement. Centripetal acceleration will cause the resin to spread and eventually off, the edge of the substrate leaving a thin film of resin on the surface. Final film thickness and other properties will depend on the property of the resin (viscosity, drying rate, surface tension, etc.) and the constraints selected for the spin procedure. Factors, for example, final rotation velocity, acceleration and fume exhaust contribute to how the features of coated films are described. One of the most significant factors in the spin coating is repeatability. Slight deviations in the parameter that define the spin procedure can result in severe variation in the coated films. The following is an explanation of a few of the effects of these variations. The schematic illustration of typical stage of the spin coating process is shown in Fig. 2 [8].

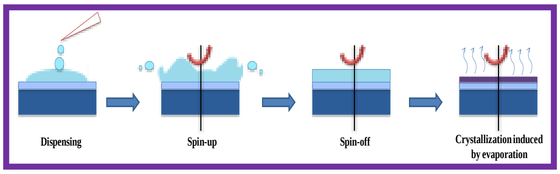

Fig. 2 Schematic illustration of typical stage of spin coating process

3.2 Chemical Bath Deposition

The Chemical bath deposition method is the cheapest technique to deposit thin films and nanomaterials, as it does not depend on costly apparatus and is a scalable method that can be used for large area batch processing or continuous deposition. It is shown in Fig. 3.

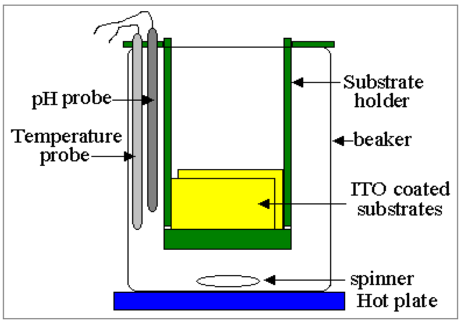

Fig. 3 Schematic illustration of Chemical bath deposition

4. Characterization

4.1 X-ray Diffraction (XRD)

X-ray diffraction (XRD) is the powerful characterization apparatus employed in the material science. The atomic planes of a crystal cause an incident beam of x-rays to interfere with one another as they move out of the crystal. The phenomenon is called x-ray diffraction. It is a material characterization method that can be helpful for investigating the lattice structure of a specimen. The sample is irradiated with nonchromatic x-ray light and the stray radiation recorded. The main field of application is the recognition of crystalline fractions in powders [9]. The x-ray radiation is emitted by copper having characteristic wavelength of the K radiation is 1.5418 Å. When the x-ray beam strikes sample diffraction occurs in every feasible orientation of 2θ. The diffracted beam may be sensed by using a moveable detector such as Geiger counter, which is attached to a chart recorder. In normal use, the counter is locate to scan over a range of 2θ values at a constant angular velocity. Routinely a 2θ range of 10 to 80° is sufficient to cover the most valuable part of the powder pattern. The scanning speed of the counter is usually 2θ of 2°/ min and therefore about 30 minutes are needed to obtain a trace.

4.2 UV- Visible Spectroscopy

Ultraviolet-visible spectroscopy refers to absorption spectroscopy in the UV-visible spectral region, i.e. utilizes light in the visible and neighboring (near - UV and near-infrared) ranges. The absorption in the visible range unswervingly affects the distinguished color of the chemicals engaged. In this area of the electromagnetic spectrum, molecule undergoes electronic transition. This method is complementary to fluorescence deals with transitions from the excited state to the ground state to the excited state. It determines the intensity of light passing through a sample (I) and compares it to the intensity of light before it passes through the sample (I_o). The ratio I/I_o is called the transmittance and is usually expressed as a percentage (%T). The absorbance, A, is based on the transmittance given in Eq. (1):

$$A = -\log\left(\frac{\%\,T}{100}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The main elements of a spectrophotometer are a light source, a holder for the sample, a diffraction grating or monochromator to divide the different wavelengths of light and a detector. The radiation source is generally a tungsten filament (300-2500 nm), a deuterium arc lamp, which is continuous over the ultraviolet region (190-400 nm) or more recently, light emitting diodes and xenon arc lamps for the visible wavelengths. The detector is typically a photodiode used with monochromators which filter the light so that only light of a single wavelength reaches the detector.

4.3 Fourier Transform Infrared (FTIR) Spectroscopy

Fourier transform Infrared Spectroscopy (FTIR) is a sensitive method mainly for recognizing organic chemicals in entire array of applications even though it can also describe some inorganic materials. Generally, the goal of FTIR spectroscopy is to determine how well a sample absorbs or transmits light at each different wavelength. To use the FTIR, a continuum source of light is utilized to create light over a wide range of infrared wavelengths. The main experimental technique in this work is FTIR, which permits us to sense infrared (IR) absorption and reflection characteristic over a wide spectral region. It is a valuable technique for the characterization of conducting polymers because it does not need polymers to be soluble in any new solvent.

4.4 Transmission Electron Microscopy (TEM)

Transmission electron microscopy (TEM) is a microscopy device in which a beam of electrons is transmitted through an ultra-thin sample, relating with the sample as it passes through it. It has been employed to study size, shape and distribution of materials at the nanoscale. An picture is formed from the interaction of the electrons transfer through the sample; the figure is magnified and focused onto an imaging tool such as fluorescent screen on a sheet of photographic film, or to be sensed by a sensor. The chief purpose of TEM is to disclose sub-micrometer inner fine structure in the materials.

4.5 Scanning Electron Microscopy (SEM)

A scanning electron microscope (SEM) is a unique type of electron microscope which creates pictures of a specimen by scanning it with a focused beam of electrons. The electrons interact with atoms in the specimen, producing several signals that can be sensed and that hold information about the specimen surface topology and composition [10]. The electrons beam is commonly scanned in a raster scan pattern and the beam's position is merged with the detected signal to create a picture. SEM can attain resolution better than 1 nm. Samples can be studied in a high vacuum, in low vacuum, in wet conditions (in environmental SEM) and at a wide range of cryogenic or elevated temperatures. The numbering of secondary electrons depends on the angle at which beam meets the surface of specimen. By scanning the specimen and collection of the secondary electrons with the extraordinary detector, a picture showing the topography of the surface is produced.

5. Conclusions

This review includes most important solar photovoltaic technologies, their synthesis, preparation methods and characterization. This paper would be useful for the academicians, researchers, generating members and decision makers.

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