DESIGN AND FABRICATION OF ZnSe BASED SOLAR CELLS

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1. Introduction

Human being has a seemingly greedy desire for energy. This hunger has gradually grown with rising population and technological progress. Our principle clarification of this mounting power generation has been to burn fossil fuels. Due to twin issues of fossil fuel exhaustion and environment dreadful conditions like global warming, ozone layer depletion, solar cells have established substantial attention as one of the most favorable devices for altering solar power to electricity.[1-2] A solar cell is a photonic device that translates photons having particular wavelengths to current. To obtain higher output, proper selection of materials having special optical and photovoltaic characteristics is necessary.[3] Theoretically, the ideal optical energy for photovoltaic application is 1.39eV.[4]

Usually, n-type window materials which, be owned by the II-VI group have been examined and applied for possible applications. Among them, zinc selenide (ZnSe) is a promising semiconductor having band energy 2.7eV, around 90% optical transparency, higher refractive index, and substantial photosensitivity.[5-6] It acts as a window layer in heterojunction solar cells. Properties of solar cells rely on the optical gap energy of semiconductors. Accordingly, numerous researchers have been developing to adjust the optical gap energy of photoelectrode applying proficient method steadily. It is a favorable substitute for the poisonous CdS buffer layer in photovoltaic cells.[7-10] The electrical characteristics of the ZnSe electrode are extremely sensitive to the crystallographic properties.

ZnSe crystals exhibit in cubic as well as hexagonal systems. The lattice constant of cubic phase are a =b = c =5.670Å and that of hexagonal are a = b =3.996 and c = 6.626Å correspondingly. It has a density of 5.27 g/cm^3. The refractive index of ZnSe is around 2.67 at 550 nm and has a significant broader transmittance wavelength range (450 to 2150 nm). The static dielectric constant of ZnSe is about 8.6 and that of high-frequency dielectric constant is 5.7.[11]

2. Photoelectrochemical cells (PEC) using ZnSe photoelectrode

The semiconductor-liquid junction photoelectrochemical solar cells the light-sensitive semiconducting photoelectrode dipped in electrolytic solution consist of appropriate redox couple and a counter electrode that might indicate metallic or semiconducting nature. Light of photon energy more than an optical gap of semiconducting material are strikes the junction, consequences in production and separation of charge carriers. In the case of n-ZnSe photoelectrode, a hole is a minority carrier that transfers to electrolytic solution and participates in electrochemical response. The majority carrier i.e. electrons are present at the counter electrode via an exterior circuit and join in a counter-reaction. Crystalline semiconducting films may too be utilized with no extreme reduction in productivity. Consequently, PEC cells deliver a cost-effective chemical path for catching solar energy.[12-13]

It involves of a hard glass vessel. An opening with dimension of 2cm×1.5cm became prepared for the enlightenment of the electrode. The cell may be signified as n-ZnSe|Electrolytic solution |$C_{(graphite)}$ Counter electrode is fabricated applying a graphite rod dipped in concentrated CoS solution for 1 day. A calomel electrode was used as a reference electrode. The uncovered area of dimension 1 cm×1 cm became open to photons. The outstanding region of the electrode became screened by the applying of epoxy resin. The representation of a PEC cell is shown in Figure 1.

Current-voltage properties of PEC cells propose the unsymmetrical nature signifying generation of rectifying nature of junction.[14] Ideality parameter was obtained to be larger than unity. The greater magnitude recommends the domination of series resistance in addition to crystallographic imperfection. It too recommends that average transfer through the electrode electrolytic solution junction having substantial involvement from surface states as well as deep traps. The alteration effectiveness is about to be 0.13% using sulphide-polysulphide electrolyte system. The lower productivity because of higher series resistance and interface states that are accountable for recombination path.[15]

Thermal treatment is essential for the construction of PEC cells. It increases cell efficiency. The output was estimated to be 0.22% when the electrode is annealed at 473K. To increase the efficiency of ZnSe electrode different metal ions were substituted. For example, Cd^{+2} ions substituted in ZnSe electrode shows the output of 0.61% using sulphide-polysulphide electrolyte system.[16-19]

The effectiveness of PEC using ZnSe electrode depends on the characteristics of an electrolytic solution. Various electrolytic solutions like sulphide/polysulphide, ferri/ferrocyanide, DMSO, Hydroquinone, iodide/triodide were applied. Mahapatraet al[20] suggests the efficiency of PEC cells using iodide/triodide system is 0.2%.

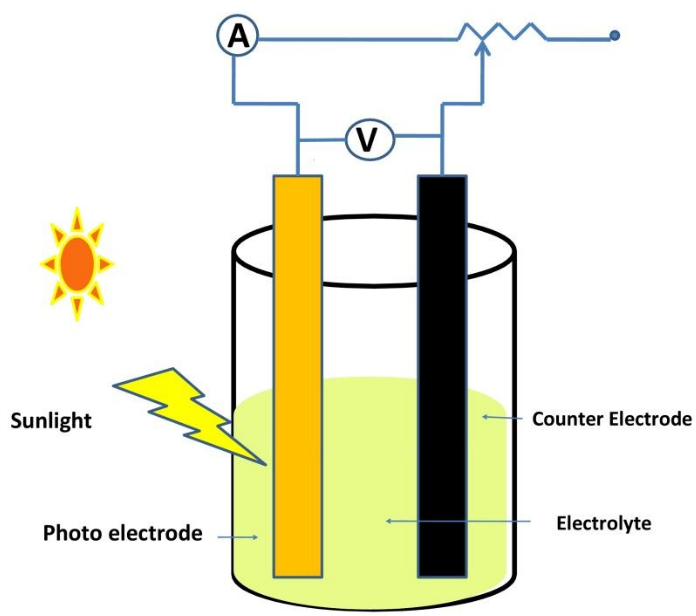

Figure 1 : Schematic diagram of Solid –Liquid junction Cell

3. Dye-Sensitized solar cell (DSSC) fabrication using ZnSe photoelectrode-

DSSC is evolving as a lower priced device. It has around better efficiency than PEC cells even under low intensity light. It is designed using the following constituents: Dye sensitized films, transparent conductive oxide (TCO) layer which assists charge transfer from the electrode layer, counter electrodes like platinum, graphite paint on Indium doped tin-oxide (ITO) glass, and redox electrolytic solution. In this device, ZnSe film acts as the electron carrier and dye layer acts as the electron producer that will recover to its original state by electron given by the electrolytic solution.[21-23] The representation of the cell revealed in Figure 2.

An electrolyte like I^-/I_3^-, Br^-/Br_2^-, SCN^-/SCN_2 and Co(II)/Co (III) was utilized. It has mainly major factor such as redox couple, solvent, ionic liquids, cations and additives.[24-25]

In the fabrication of DSSC, ZnSe nano particles are mixed with acetic acid and crushing in mortar. A uniform sheet of ZnSe is coated on ITO glass. It is heated in a furnace at 150˚C for 60 minutes. This glass plate has positioned in anthocyanin dye for 10 minutes. Spread over graphite paint on another ITO coated glass. Align two conductive glass plates, placing one upside down while the one to be coated is right side up. Two binder clips are placed on long edges to hold plates together. Place 2-3 drops of iodide/ KI electrolytic solution at one edge of the plate. Two binder clips act as two electrodes.

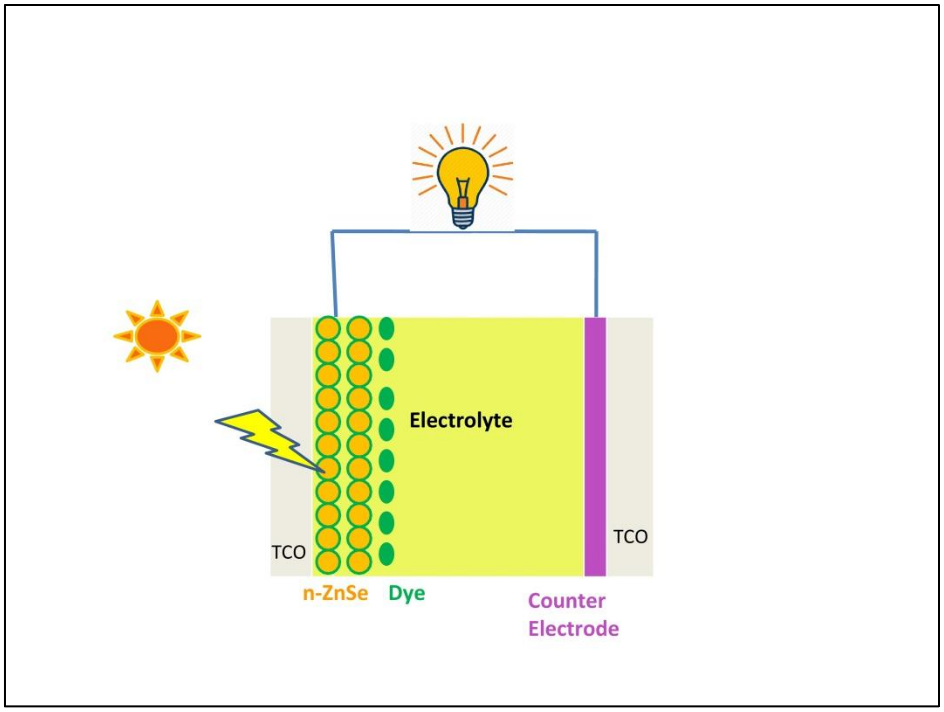

Figure 2: schematic diagram of Dye-Sensitized solar cell

For the design of DSSC, ZnSe photoanode became coated on the ITO glass electrode. To sensitized, it was immersed in an ethyl alcohol and eosin yellowish dye for 15 hours. Sensitized ZnSe film became dried at 60^0C for 15 minutes. Carbon coated glass was used as the counter electrode. The electrodes were brought together into a sandwich kind cell. The active area was $1cm^2$. A droplet of an electrolytic solution having KI and Iodine in acetonitrile became introduced into the cell. The efficiency of 8.9 % was achieved.[26] Li et al[27] suggested ZnSe can be counter electrode to replace rare and expensive Pt. ZnSe was mixed with a conducting binder, poly(3,4-ethylene-dioxythiophene):poly(styrenesulfonate) and coated on to ITO substrates through a drop-coating process. The optimized concentration of ZnSe found to be 10 wt%. The power output obtained was 8.13%.

ZnSe is appropriate passivation material to form a type II core or shell structure for CdSe/CdS quantum dots. ZnSe treatment may efficiently shield the bare $TiO_2$and quantum dots, subsequent in strong inhibition of the electron leak from both TiO_2 and quantum dots to the electrolytic solution, as a result considerably improving the output of DSSC.[28]

I^-/I_3^- have been established as an extremely effective electrolytic solution. There are certain limits connected with its uses. This electrolytic solution disintegrates photoelectrode, it is extremely unstable and accountable for degradation and dyes desorption and has poor long term steadiness. Acetonitrile, N-methyl Pyrrolidine, and solvent mixtures such as Acetonitrile/valeronitrile have been used as a solvent having high dielectric constant.[29-30]

4. Heterojunction solar cell using ZnSe photoelectrode-

It is a semiconductor-semiconductor junction type of solar cell. The heterojunction is a junction designed among two semiconducting materials having diverse optical gaps. Photon having energy fewer than optical energy of first semiconductor however larger than optical energy of second semiconductor will cross first semiconductor, which works as a window, be absorbed by the second semiconductor. Charge carrier produced in the depletion area and within diffusion length of the junction will be collected, alike to an n-on-p homojunction solar cell. Photons having energy greater than optical energy of the first semiconductor will absorb, and carriers produced within a diffusion length from the junction or in the depletion area will be collected.

There are some benefits related with ZnSe heterojunction based solar cells above silicon homojunction. Above optical energy photons are absorbed by ZnSe n-type layer formerly they may reach and destruction of p-n junction. Another advantage is that junction may be kept deeper within the cell away from lifetime killing surface states consequently growing competence since greater optical energy ZnSe layer is transparent most of the solar spectrum. Due to this decreases the series resistance of the window.[31]

The solar cells having the inverted structure of ITO/ZnO/ZnSe/CdTe/MoOx/Au are designed. ZnO coated on ITO templates and heated at 400^0C for 10 min. Several drops of ZnSe nano crystals are put on top of the ITO/ZnO templates. ITO/ZnO/ZnSe sample is heated at 150^0C for 3 min. The thickness of ZnSe nanocrystals having a layer is approximately 20 nm. Some droplet of 1% ethylene diammine tetra acetic acid methanol solution is placed on top of ZnSe nanocrystal. After this, five layers of CdTe nano crystals having a thickness of around 450 nm are coated on the templates. Afterward, a few droplets of saturated cadmium chloride in methanol are placed on top of the ITO/ZnO/ZnSe/CdTe.MoOx having thickness approximately 8 nm and Au of 80 nm back contact are deposited. The active area of the cell was 0.16 cm^2. The power efficiency 3.58% for this cell.[32] Figure 3 indicates the heterojunction solar cell using ZnSe photoelectrode.

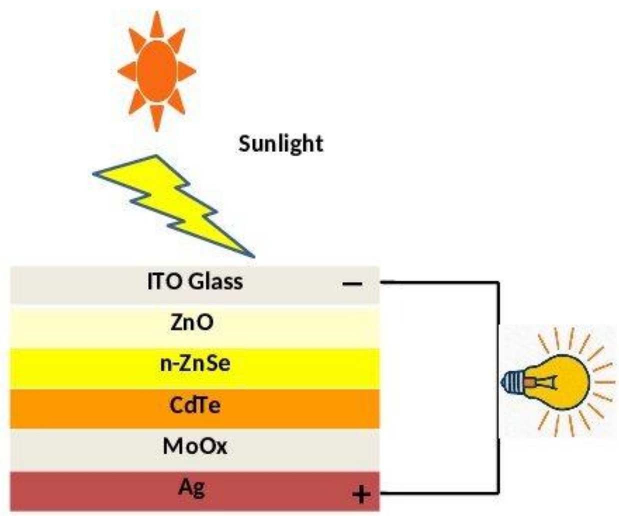

Figure 3 : Schematic diagram of Solid -Solid Hetrojuction Cell

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