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 to utmost favorable instruments for altering solar power to electrical energy.[1-2] A solar cell is a photon based device which 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 compounds were examined. These are found to be applicable for possible uses. Out of II-VI compounds, zinc selenide (ZnSe) is a favorable semiconducting material having band energy 2.7eV, around 90% optical transparency, higher refractive index, and substantial photosensitivity.[5-6] It acts as a window sheets in heterojunction 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 cadmium sulphide layers in photovoltaic devices.[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. The photon energy more than optical gaps 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 |$C_{(graphite).}$ The counter electrode is fabricated applying graphite dipped in the conc. Cobalt sulphide solution for 1 day. A calomel electrode became utilized 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 due to higher series resistance as well as interface states that responsible for re-combination path.[15]

Thermal treatment is essential for the construction of PEC cells. It increases cell efficiency. When the photoelectrode is heated at 200^0C, the output was estimated 0.22%. To increase the competence 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 0.21%.

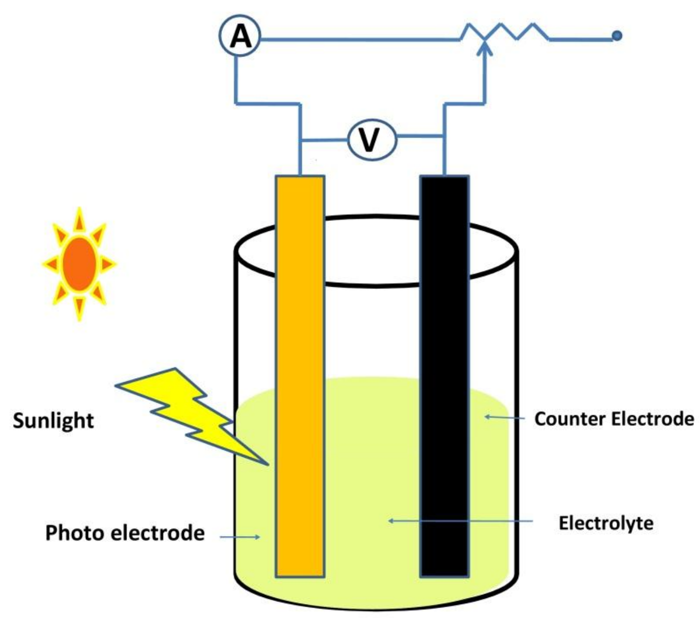

Figure 1 : Schematic diagram of Solid –Liquid junction Cell

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, translucent conductive oxide (TCO) coating that assists charge transfer as of the photoelectrode 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 transporter and dye coating acts as electron producer that will recuperate to its unique state by electron given by the electrolytes.[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 placed in a heating system at 140˚C for one hour. Obtained templates has positioned in anthocyanin for few minutes. Spread over graphite paint on another ITO coated glass. Make parallel two conductive templates, kept one upside down and another to be covered is right side up. 2 binder pins are kept on long edges to grip plates organized. Pour 2 to 3 drops of KI/iodide electrolyte. 2 binder pins act as electrodes.

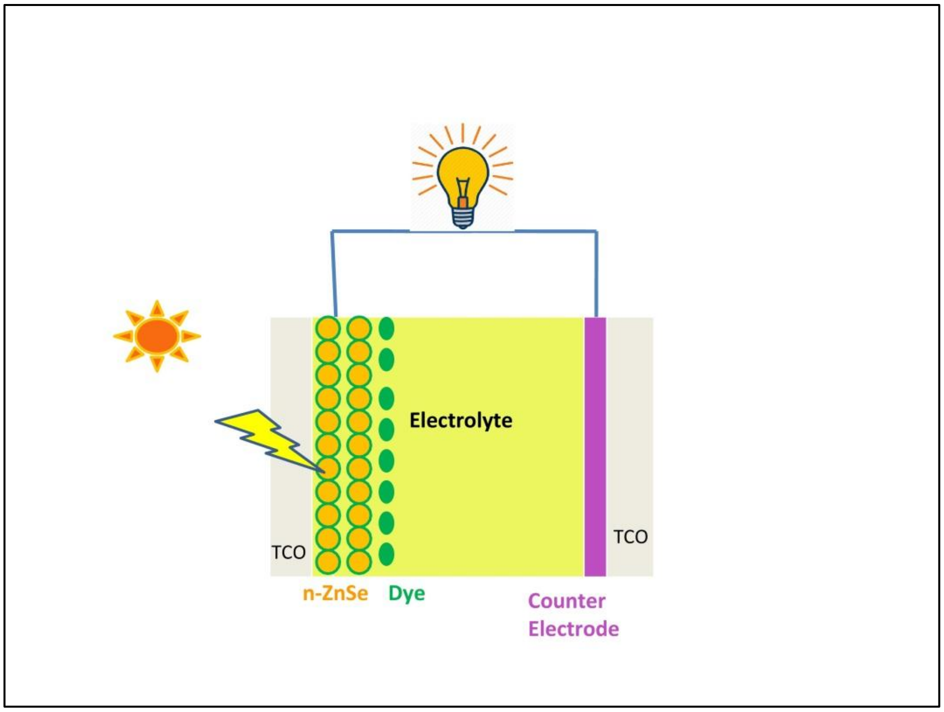

Figure 2: schematic diagram of Dye-Sensitized solar cell

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 few minutes. Carbon covered glass became utilized as 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 dissolved in acetonitrile became introduced into the device. The efficiency of 8.9 % was achieved.[26] Li et al[27] suggested ZnSe can be counter electrode to swap costly platinum. ZnSe was added with binder, poly(3,4-ethylene-dioxythiophene):poly(styrenesulfonate) and coated on to Indium tin oxide templates over a drop-coating method. Optimized concentration of ZnSe found to be 10 wt%. The power output obtained was 8.13%.

ZnSe is appropriate passivation substance to generate a type II core or shell arrangement for CdSe/cadmium sulphie quantum dots. ZnSe may efficiently shield bare $TiO_2$and quantum dots, subsequent in inhibition of the electron leak as of 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. It has poorer steadiness. N-methyl Pyrrolidine, Acetonitrile and mixtures of Acetonitrile/valeronitrile have been applied. Solvent must have 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 that works as an opening for the second semiconductor. Charge carrier produced in this area and within diffusion length of the junction will be collected, alike to an n-on-p homojunction cell. First semiconductor will capture the energy, when the photons having higher energy compare to optical energy.

There are some benefits related with ZnSe heterojunction based solar cells above silicon homojunction. The destruction of junction takes place when the energy of photons capture by ZnSe n-type coating. Another advantage is that p-n junction may be kept deeper within the cell away from lifetime killing surface states. Consequently growing competence since greater optical energy ZnSe coating is transparent to the solar spectrum. Due to this decreases the series resistance of the window.[31]

Solar cells having the reversed structure of ITO /ZnO /ZnSe /CdTe /MoOx /Au are designed. ZnO coated on ITO templates and heated at 400^0C for 10 min. A few droplets of ZnSe nano crystals are pour upper side of the ITO/ ZnO templates. ITO/ZnO/ZnSe became heated at 150^0C for few minutes. 20nm thickness of zinc selenide nanocrystals was used. Some droplet of 1% ethylene diammine tetra acetic acid methanol solution is placed on top of ZnSe nanocrystal. After that, 5 sheets of cadmium telluride nano crystals of around 450nm are coated on the templates. Afterward, a few droplets of saturated cadmium chloride in methanol are placed on upper side of the ITO/ ZnO/ ZnSe/ CdTe.MoOx having thickness approximately 8 nm are deposited. The back contact of 80nm of gold are coated. 0.16 cm^2 area was utilized for solar energy production. The power efficiency 3.58% for this cell.[32] Figure 3 indicates the heterojunction solar cell using ZnSe photoelectrode.

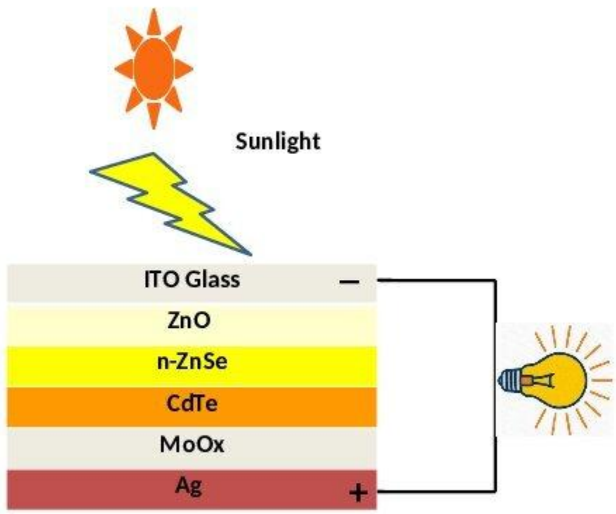

Figure 3 : Schematic diagram of Solid -Solid Hetrojuction Cell

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