



Solar Cell Nano Thin Films and Polymer: An Alternative to Fossil Fuels and act as a Green Energy

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Abstract : Solar cells, also known as photovoltaic cells, are devices that convert the sun's energy into electricity. They are made up of semiconductor materials, typically silicon, which absorb photons from sunlight and release electrons, creating an electric current. Solar cells work on the principle of the photoelectric effect, where the absorption of photons by semiconductor material causes electrons to move freely and generate an electric current. The key component of a solar cell is the p-n junction, a boundary between two layers of semiconductor materials with different electrical properties. When light hits the cell, it creates electron-hole pairs, and the electric field at the p-n junction separates the charges, allowing the electrons to flow in one direction and create an electric current.

Solar cells come in various types, including monocrystalline, polycrystalline, and thin-film solar cells. Monocrystalline cells are made from a single crystal structure, offering the highest efficiency but at a higher cost. Polycrystalline cells are made up of multiple crystal structures and are less expensive but slightly less efficient. Thin-film solar cells use a thin layer of semiconductor material and are more cost-effective but have lower efficiency.

Solar cells are widely used in solar panels to generate electricity for residential, commercial, and industrial purposes. They can be installed on rooftops, in solar farms, or in space satellites. Solar energy is a renewable and sustainable source of electricity and helps reduce greenhouse gas emissions and dependence on fossil fuels.

Advancements in solar cell technology continue to increase their efficiency and reduce costs, making solar power more accessible and widely adopted as a clean energy solution.

Index Terms - Solar Cells, Nano Thin Films, Electrodeposition, Green Energy, Polymer, ITO

I. INTRODUCTION

Solar cells are a promising alternative to fossil fuels for electricity generation. Solar cells, also known as photovoltaic cells, convert sunlight directly into electricity. Here are some of the key advantages of solar cells as an alternative to fossil fuels:

1. Renewable Energy Source: Solar energy is a clean and abundant resource that will never run out as long as the sun shines. Fossil fuels, on the other hand, are finite resources that are being depleted at a rapid rate.

2. Environmentally Friendly: Solar cells produce electricity without emitting any harmful pollutants or greenhouse gases. This helps to mitigate climate change and reduce air pollution, improving both local and global environmental conditions.

3. Energy Independence: Solar cells allow individuals, households, and communities to generate their electricity. This reduces reliance on centralized power grids and external energy sources, providing greater energy independence and security.

4. Cost-Effective: The cost of solar cells has been decreasing steadily over the years, making them more affordable and cost-competitive with fossil fuels. Additionally, solar energy has low operating costs and can provide long-term savings on electricity bills.

5. Job Creation: The solar industry is a rapidly growing sector that creates numerous job opportunities in manufacturing, installation, maintenance, and research and development. This can stimulate economic growth and contribute to the creation of a sustainable workforce.

6. Distributed Generation: Solar cells can be installed on rooftops or in decentralized locations, reducing the need for extensive transmission and distribution networks. This enhances energy resilience and reduces the risk of power outages.

While solar cells have many advantages, there are still challenges to address. These include the intermittency of solar power (as it relies on sunlight), the need for energy storage solutions, and the requirement for suitable locations for solar installations. However, advancements in technology and the integration of energy storage systems are helping to address these challenges and make solar cells an increasingly viable alternative to fossil fuels.

1.1 THIN FILM SOLAR CELLS:

Thin film solar cells have the advantage of being lightweight and flexible, making them suitable for a wide range of applications and locations. This enables distributed generation, where solar cells can be integrated into various surfaces and structures, such as rooftops, windows, and even clothing.

Distributed generation allows for energy production at the point of consumption, reducing transmission losses and the need for extensive infrastructure. This can lower costs and improve grid resilience by decentralizing electricity generation.

Thin film solar cells also have the potential to be produced at a lower cost compared to traditional crystalline silicon cells. They require less material and can be manufactured using low-cost and scalable techniques, such as roll-to-roll printing or sputtering. This makes them an attractive option for mass production and widespread deployment.

Additionally, thin film solar cells have a higher performance in diffuse and low-light conditions compared to crystalline silicon cells. This means they can generate electricity more efficiently in cloudy or shaded environments, making them suitable for a wider range of locations and climates.

However, thin film solar cells currently have lower efficiency levels compared to traditional silicon solar cells. This means a larger surface area is required to generate the same amount of power, which can limit their application in space-constrained areas.

Despite these limitations, ongoing research and development in thin film technologies aim to improve their efficiency and reduce costs, making them an increasingly viable option for distributed generation of solar energy.

Zinc Cadmium (ZnCd) thin film solar cells are a specific type of thin film solar cell that utilize a combination of zinc and cadmium as the active semiconductor material. ZnCd thin film solar cells are commonly categorized as II-VI compound thin film solar cells, along with other materials like cadmium telluride (CdTe) and copper indium gallium selenide (CIGS).

ZnCd thin film solar cells offer several advantages. They can be fabricated using low-cost and scalable manufacturing processes, such as chemical bath deposition or evaporation. The combination of zinc and cadmium allows for bandgap engineering, which means that the energy levels at which photons are absorbed can be adjusted, improving efficiency.

One of the main challenges with ZnCd thin film solar cells is the toxicity and environmental impact associated with the use of cadmium. Cadmium is a heavy metal that is considered toxic and poses risks to human health and the environment. Therefore, efforts are underway to find alternative materials or reduce the amount of cadmium used in these cells.

Despite the challenges, ZnCd thin film solar cells have demonstrated promising efficiency levels, with some research achieving efficiencies comparable to or even exceeding that of other thin film technologies. Ongoing research aims to further improve the efficiency and reduce the manufacturing cost of ZnCd thin film solar cells, making them a potential option for commercial use in the future.

1.2 PHOTOVOLTAIC CELL

Photovoltaic was considered an acceptable area of study only after the concept of photons and electrons was introduced with the beginnings of quantum mechanics. Scientific models were finally equipped to deal with the concept of light absorption. In 1931, the German Scientist, Bruno Lange, rediscovered the selenium-based photovoltaic cell. The promise for inexhaustible, pollution-free energy created a lot of excitement. However, the selenium-based photovoltaic cell converted less than 1% of the incoming sunlight into energy, which was far too low to justify it as a practical power source. Researchers and the public did not get excited about photovoltaics again until the 1950's with the beginning of silicon transistor technology. In 1954, Calvin Fuller and Gerald Pearson, of Bell Labs, discovered that the efficiency of silicon rectifiers (which convert AC to DC) changed depending on their purity as well as the lighting conditions. They soon discovered that the rectifiers converted 4% of the incoming sunlight into electrical energy. Along with Darryl Chapin, a colleague, Calvin Fuller and Gerald Pearson started a team to work on what they named the Bell Silicon Battery. Further research increased the efficiency to 15% and soon limited markets for silicon photovoltaic cells were discovered. They were first used as a power source for a telephone relay system in an isolated rural area; however an economic analysis later revealed that a conventional power supply would have been better. Plans were laid out to use them at national forest lookout posts and Coast Guard buoys, but government agencies anticipated that small nuclear power systems would be better. At this point, no commercially viable applications could be found for silicon photovoltaic cells on earth but they were soon found above the earth, in space. The space race began in the late 1950's and designs for satellites called for a long-term power source that was compact and light weight. Conventional fuels systems and batteries were far too bulky and heavy; in addition, fuel was expendable. Depending on the altitude and direction of the orbit, satellites could be exposed to the sun almost continuously. Because of these advantages the U.S. space program created the now viable silicon photovoltaic cell industry [1]. In 1958, six small silicon solar panels, providing 100 mW of power were included on the satellite Vanguard I. Since then, the global photovoltaic production has gone from 100 mW to over 200 MW in 1999. Terrestrial applications make up the most of this as space systems consist of less than 1% of the industry [2]. In order for a material to convert light into electrical energy, it must satisfy two conditions. First, it needs to be able to absorb incident photons through the promotion of electrons to higher energy levels. Second, it must contain an internal electric field that accelerates the promoted electrons in a particular direction, resulting in an electrical current. From the most basic point of view, a photovoltaic cell can be thought of as any device when exposed to light that causes current to flow in an electrical circuit with a given load resistance (e.g. wires plus a light bulb). [1] For the following discussion, let us fix the intensity of the incoming light as I_1 , and just vary the load resistance. If the resistance is infinite, the current will be zero. This is called the open circuit condition. In this case, the photons continue to generate pairs of electrons and holes within the photovoltaic material. The internal electric field separates the electrons and holes and accelerates them in opposite directions creating a voltage difference on either side of the photovoltaic cell. The magnitude of this voltage drop is called the open circuit voltage, V_{oc} . The open circuit voltage scales with the intensity of light, but for a given intensity, the voltage remains constant with time. The reason it remains constant, despite the fact that photons are continually absorbed, is that the generated electron-hole pairs recombine at a certain rate at defects and surfaces. Because of this, the open circuit voltage is a good measure for the quality of the photovoltaic cell the higher the open circuit voltage, the more efficiently the cell can convert photons into electrical energy. Under these conditions the photovoltaic cell is said to be in its short circuit configuration and the current is called the short circuit current, I_{sc} . Note that through $V = I R$, the voltage drop is also zero. The short circuit current is also limited by the recombination rate of the material and is a good measure of the quality of the photovoltaic cell. In order to maximize the efficiency of a photovoltaic cell, researchers and engineers attempt to maximize the open circuit voltage and short circuit current by removing recombination sites. In between these two extremes when there is a finite resistance in the circuit the current and voltage are both less than their maximum values and are related to the load resistance through Ohm's Law, $V = I R$. The power that is supplied as a result of the load resistance (e.g. the light bulb) is the product of the current and the voltage. For a higher load resistance, the voltage is increased but the current is decreased. For a lower load resistance, the voltage is decreased but the current is increased.

The following problems of $Zn_{1-x}Cd_x(O)/Polymer$ based photovoltaic cells.

(i) The increasing global demand to renewable energy such as solar energy, and the negative impact of the current sources of energy i.e. the fossil fuels.

(ii) The high cost that leads to replace silicon by another material such as ZnO and CdO prepared by electrodeposition technique which is rather cost effective and time efficient than the silicon wafer technology, and the polymer i.e. PEO - Chitosan synthesized by solution casting technique is also cost effective than other techniques for manufacturing silicon wafers for photovoltaic cells.

(iii) Another aspect which warrants detailed analysis is the enhanced stability of $Zn_xCd_{1-x}O$ devices. The stability of the devices may increase due to two main aspects. Use of $Zn_xCd_{1-x}O$ can increase the effective area of the cell, resulting in better yield for a given volume of absorber layer. Reduced amounts of sensitive organic material should lead to better stability in performance. Although many researchers were able to fabricate various shapes of $Zn_xCd_{1-x}O$ thin films via electrodeposition, the efficient control of crystal shape still remains a challenge.

(iv) Also, organic material systems are highly susceptible to heat, resulting in poor performances upon exposure to temperatures above a couple of hundred degrees. Therefore, it may in some instances be preferable to develop low-resistance Ohmic contacts such as PEO-Chitosan. The materials that are currently being used to fabricate these photovoltaic cells have a shortcoming i.e. they are not able to absorb enough energy from the sun and are not thus efficient enough. To optimize the absorption of solar energy, other 16 materials are being looked upon and $Zn_xCd_{1-x}O$ /Polymer can be a viable option. Therefore, more thorough fundamental understanding is needed to advance $Zn_xCd_{1-x}O$ /Polymer based photovoltaic technology.

2 EXPERIMENTATION SET UP

The material selected as the substrate was Indium-Tin-Oxide (Aeroxid p25 Japan). The ITO glass was cut into 2 cm x 2 cm by using a diamond cutter. The chemicals that were used in this experiment are zinc chloride ($ZnCl_2$), (Sigma Aldrich, $\geq 99.0\%$) and cadmium chloride ($CdCl_2$). They were used without further purification. While for the counter electrode platinum sheet was used as the anode, and ITO substrate as the cathode.

2.1 FABRICATION OF SAMPLES FOR ELECTRODEPOSITION PROCESS

The chemicals used in this research were taken from commercial sources and of the highest purity available. They were used without further purification. The transparent conductive oxide (TCO) glass substrates consisted of indium doped tin oxide coated on soda-lime glass. The strips were cut by using diamond cutter, followed by cleaning in four five minute steps of cleansing in ultrasonicated acetone, distilled water, ethanol, and finally de-ionized water. All solutions used as an electrolyte were prepared from distilled water.

Table 1 Materials and equipment's needed for cleaning ITO substrate

Materials/Chemicals	Equipment's/Tools
Acetone	Tissue
Distilled water	Tweezer
De-ionized water	Ultrasonic Bath
Ethanol	Beaker
	Ammeter

2.2 SYNTHESIS OF ZnO, CdO AND $Zn_xCd_{1-x}O$ THIN FILMS

Zinc oxide thin films were electrodeposited from a zinc chloride electrolytic bath of 25 mM $ZnCl_2$. Films were grown at -1.5 V for a nominal duration of 30 minutes. The deposition bath temperature was maintained at 80 °C - 100 °C. After electrodeposition, the samples were removed, cleaned with deionized water and stored in petri dishes. For each parameter five samples were prepared. The petri dishes were covered with aluminum foil in order to prevent oxidation.

Mixed oxide thin films, $Zn_xCd_{1-x}O$ were electrodeposited from an electrolytic bath consisting of zinc chloride and cadmium chloride in different ratios in the solution (Table 1). The films were grown at a deposition potential of -1.5 V. The temperature of deposition was maintained at 80 °C to 100 °C and the process duration was 30 min. The samples on which $Zn_xCd_{1-x}O$ thin films were cleaned and stored in the aluminum foil covered petri dishes.

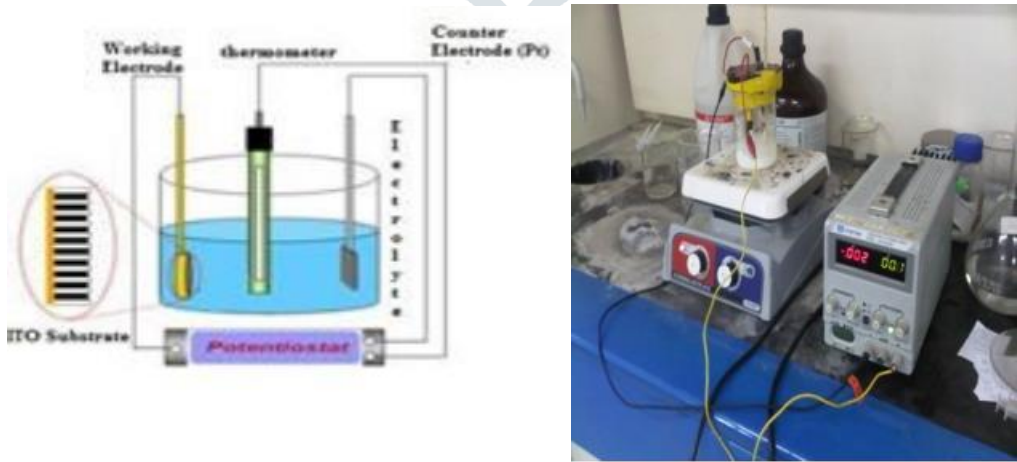


Figure 1 Experimental setup for electrodeposition

Electrodeposition had been proven to be the most efficient method to produce homogeneous $\text{Zn}_x\text{Cd}_{1-x}\text{O}$ thin films since it is an efficient, cost effective and large scale method. The solution growth process was based on the reaction of cadmium salt, zinc salt, a complexing agent in a heated aqueous solution. Figure 1 showed the setup for electrodeposition for the synthesis of oxide films.

Setup as shown in Figure 3.1 showed that the indium tin oxide coated substrates (ITO) were immersed in the bath containing water and the solution of zinc Chloride (ZnCl_2) and cadmium Chloride (CdCl_2) and heated from 80°C to 100°C . The deposition parameters such as temperature, time and composition control the structure of the film [3]. The amount of particulates on the surface of the solution was minimized by continuous stirring. The films deposited on SnO_2 coated glass substrate (ITO) were more adherent than on glass because of conductivity of the former. The thickness of $\text{Zn}_x\text{Cd}_{1-x}\text{O}$ increases with increasing time of deposition

Table 2 Ratio of $\text{Zn}^{2+}:\text{Cd}^{2+}$ species in solution for electrodepositing $\text{Zn}_x\text{Cd}_{1-x}\text{O}$ thin films

Thin Film	Zinc Chloride (mM)	Cadmium Chloride (mM)
ZnO	50	-
$\text{Zn}_{0.8}\text{Cd}_{0.2}\text{O}$	40	10
$\text{Zn}_{0.6}\text{Cd}_{0.4}\text{O}$	30	20
$\text{Zn}_{0.5}\text{Cd}_{0.5}\text{O}$	25	25
$\text{Zn}_{0.4}\text{Cd}_{0.6}\text{O}$	20	30
$\text{Zn}_{0.2}\text{Cd}_{0.8}\text{O}$	10	40
CdO	-	50

Table 3 Deposition on the basis of temperature

SAMPLE	TEMPERATURE ($^\circ\text{C}$)	VOLTAGE (V)	TIME (min)
1	80°C	-1.5 V	30 minutes
2	90°C	-1.5 V	30 minutes
3	100°C	-1.5 V	30 minutes

Cadmium oxide thin films were electrodeposited from a cadmium chloride bath which consisted of 25 mM CdCl_2 . Films were grown at -1.5 V and the deposition bath temperature was varied from 80°C - 100°C . The electrodeposition process was conducted for duration of 30 min. After completion, the samples on which thin films of CdO were grown are removed, cleaned and stored in an aluminum covered petri dishes.

A standard single-compartment, two electrode cell was used for film preparation. A platinum (Pt.) foil used as a counter electrode and ITO glass as a working electrode completed the cell set-up. During the electrodeposition oxygen was purged into the bath and the pressure of oxygen was maintained during film deposition by using pressure gauge. Depositions were carried at 80°C - 100°C and the characterizations were performed at laboratory room temperature ($\pm 25^\circ\text{C}$). The deposition potential was maintained at -1.5 V by using DC power supply.

3 RESULTS AND DISCUSSION

3.1 PHOTOVOLTAIC CHARACTERISATION

The electrical behaviour of the device depends on the individual junction created at the interface of different layers. The ITO layer behaves like traditional conductors below their Plasmon frequency and can be treated as metal for the low frequency electrical signal. $\text{Zn}_x\text{Cd}_{1-x}\text{O}$ is inherently n-type semiconductor acting as a source of photo-generated carriers and PEO-Chitosan is used as host for electron mobility. There are three junctions involved at the interface of ITO/ $\text{Zn}_x\text{Cd}_{1-x}\text{O}$ (O), $\text{Zn}_x\text{Cd}_{1-x}\text{O}$ (O)/PEO-Chitosan and ITO/PEO-Chitosan if accidental contact happens due to the porous nature of the $\text{Zn}_x\text{Cd}_{1-x}\text{O}$ (O) film. Short circuit current (I_{sc}) and open circuit voltage (V_{oc}) have been measured on 1 mm^2 effective area for devices having different concentration of x in $\text{Zn}_x\text{Cd}_{1-x}\text{O}$ (O) layer of n-type material from the figure 2. It can be seen from Table 4 that the material combination used in this work exhibits higher I_{sc} and V_{oc} compared to the earlier reported TiO_2 based PV cell which uses solid polymer electrolyte [4]. V_{oc} is found to increase when x in $\text{Zn}_x\text{Cd}_{1-x}\text{O}$ (O) layer increases up to 0.6. In contrary, large I_{sc} is recorded at higher zinc oxide (ZnO) concentration and lower cadmium oxide (CdO) concentration.

The optimization of the $\text{Zn}_x\text{Cd}_{1-x}\text{O}$ (O) layer on the basis of composition and temperature as well as investigating the current 44 transport mechanism of the device. The type of PV cells reported here shows large dark V_{oc} (0.2 V) immediately after the fabrication. After sometime (more than a week) long shortening of the two terminals, dark V_{oc} decreases and becomes negligible. However, dark I_{sc} values show negligible variations due to shortening.

The current-voltage characteristics of ITO/ $\text{Zn}_x\text{Cd}_{1-x}\text{O}$ (O)/PEO-Chitosan/ITO photovoltaic cells have been recorded in darkness and under 100 mW/cm^2 (AM of 1.5) illuminations, point by point. The measurement was carried out using an artificial

light source with additional I-V characteristics. After that I-V characteristics were recorded with continuous illumination. It is noted that the open circuit voltage V_{oc} and the short circuit current density I_{sc} decrease with increase in temperature. V_{oc} drops because of increase in reverse current saturation with temperature because minority carriers increase with increase in temperature and I_{sc} decrease because of increase in the recombination of the charge carriers.

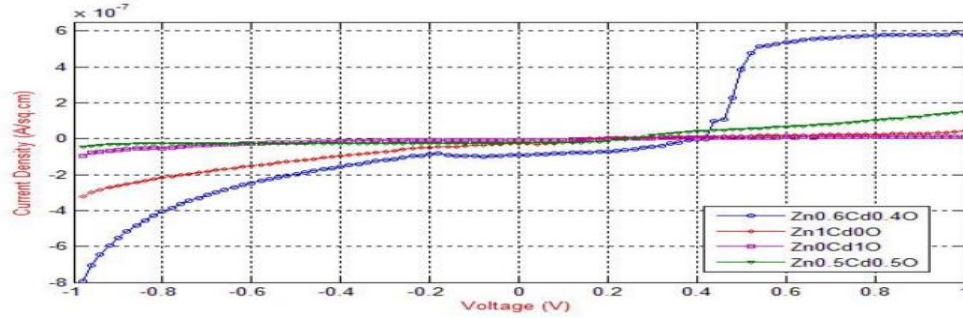


Figure 2 J-V characteristic curve of ITO/ $Zn_xCd_{1-x}O$ /PEO + Chitosan/ITO PV cell at various ratios of x under illumination condition

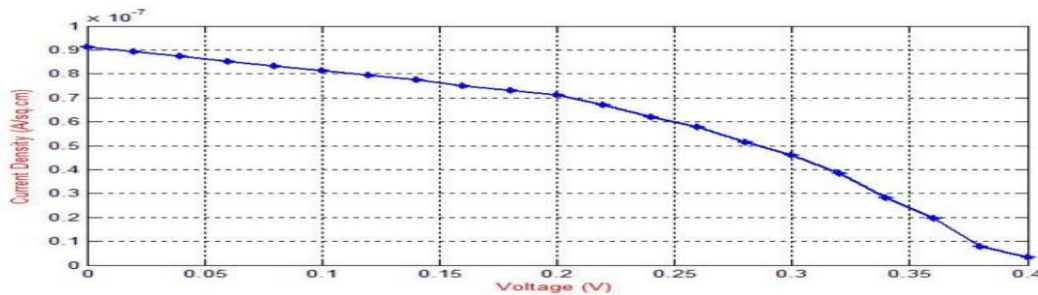


Figure 3 Reverse Bias of ITO/ $Zn_{0.6}Cd_{0.4}O$ /PEO + Chitosan/ITO PV cell under illumination condition

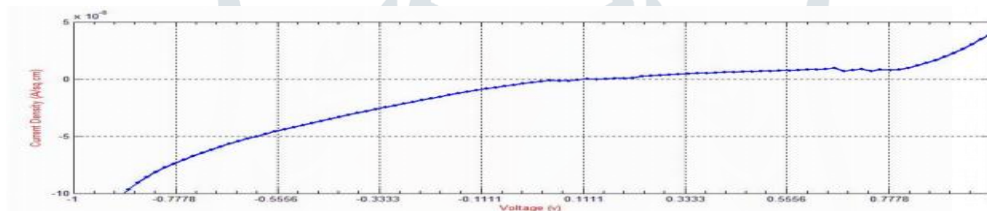


Figure 4 Diode like J-V characteristic curve of PV Cell under dark condition

For the Figure 4, the V_{oc} of the given photovoltaic cell i.e. Zn_1Cd_0O /PEO - Chitosan cell under illumination is 160 mV and the current density is in milli amperes ~ 2.9 mA/cm². Also, from the figure we can calculate the maximum current (I_p) which is 2.0 mA, maximum voltage (V_p) is 120 mV, fill factor (FF) can be calculated by using the equation $FF = \frac{V_p I_p}{V_{oc} I_{sc}}$ and efficiency (η)

of the given cell by using the equations $\eta = \left[\frac{V_p I_p}{P_{in}} \right]$ whereas the value of P_{in} is 100mW/cm². Also, from the Figure 5, the V_{oc} 's of the cells under illumination are 240 mV, 490 mV, 260 mV and 180 mV respectively and the current densities are 0.95 mA/cm², 10 mA/cm², 2.4 mA/cm² and 0.9 mA/cm² respectively. Also, from the respective figures the maximum voltages of the cells are 100 mV, 370 mV, 150 mV and 90 mV. For the current densities it is 0.7 mA/cm², 4.6 mA/cm², 2.3 mA/cm² and 0.8 mA/cm². The fill factor and efficiencies of the respected photovoltaic cells can be obtained by putting the respective values of the cells in the above mentioned equations. Among all photovoltaic cells the highest efficiency is given for the cell $Zn_{0.6}Cd_{0.4}O$ /PEO - Chitosan i.e. 1.702 %. The comparison for V_{oc} , I_{sc} , fills factor, maximum power point and efficiency for Zn_1Cd_0O /PEO + Chitosan, $Zn_{0.4}Cd_{0.6}O$ /PEO + Chitosan, $Zn_{0.5}Cd_{0.5}O$ /PEO + Chitosan, $Zn_{0.6}Cd_{0.4}O$ /PEO + Chitosan and Zn_0Cd_1O /PEO + Chitosan are tabulated in the Table 4 as follows:

Table 4 Open-circuit Voltage (V_{oc}), Short-circuit Current (I_{sc}), Fill factor (FF) and efficiency (η) of the PV Cells fabricated

PV Cell	$V_{oc}(mV)$	$I_{sc}(mA/cm^2)$	$FF = \frac{V_P}{V_{oc}}$	$\eta = \left[\frac{V_P I_P}{P_{in}} \right]$
	Light	Light		
Zn ₁ Cd ₀ O/PEO – Chitosan	160	2.9	51.7%	0.24%
Zn ₀ Cd _{1.0} O/PEO + Chitosan	240	0.95	30.7%	0.175%
Zn _{0.6} Cd _{0.4} O/PEO + Chitosan	490	10	34.7%	1.702% *
Zn _{0.5} Cd _{0.5} O/PEO + Chitosan	260	2.4	55.2%	0.345%
Zn _{0.4} Cd _{0.6} O/PEO + Chitosan	180	0.9	44.4%	0.072%

A result from the previous research by [5] and others mentioned in the literature review is tabulated Table 5 which makes a direct comparison of the results in Table 4.

Table 5 Open-circuit Voltage (V_{oc}), Short-circuit Current (I_{sc}), Fill factor (FF) and efficiency (η) of the OPV Cells fabricated (Baek et al., 2009)

PV Cell	$V_{oc}(mV)$	$I_{sc}(mA/cm^2)$	$FF = \frac{V_P I_P}{V_{oc} I_{sc}}$	$\eta = \left[\frac{V_P I_P}{P_{in}} \right]$	Reference
P3HT:PCBM	0.603	7.2	49%	2.11	(Baek, 2009)

4. CONCLUSION

Nanostructured Zn_xCd_{1-x}(O) hexagonal rods were prepared by electrodeposition technique at -1.5V by using electrolytes of ZnCl₂ and CdCl₂ in different ratios of molar concentration at temperatures of 80 °C, 90 °C and 100 °C. Electrolytic bath of 0.6 mM ZnCl₂ and 0.4 mM CdCl₂ produced electrodeposits of mixed zinc-cadmium oxide thin film on indium coated tin glass (ITO) substrate at a temperature of 90 °C. This substrate on which Zn_{0.6}Cd_{0.4}O thin film was deposited was used as one electrode of the solar cell. The other electrode which is a PEO + Chitosan thin film was prepared by solution casting technique.

The patterns obtained from X-ray diffraction, SEM and FESEM were used as the main tools to identify variation zinc, cadmium and mixed zinc-cadmium oxide. At least the deposits from Zn_{0.4}Cd_{0.6}O – Zn_{0.6}Cd_{0.4}O grown at 90 °C for 30 minutes of duration, minimum variation in the properties of electrodeposits could be expected. Also, from the X-ray diffraction (XRD) patterns it's confirmed that the thin films were polycrystalline and cubic (111) or hexagonal (002) oriented. It is seen with the increase in temperature the density of the deposition on the ITO substrate increase and nano results of these thin films were confirmed by field emission scanning electron microscopy (FESEM). The FESEM images obtained at temperature 90 °C and composition Zn_{0.4}Cd_{0.6}O produces regular hexagonal nanorods of 63.6 nm. From the UV visible spectroscopy it's seen that the band gap for zinc oxide is 3.3eV, cadmium oxide is 2.2eV and for blend zinc-cadmium oxide ranges from 2.75 – 3.02eV depending on the amount of cadmium substitution. The cut-off wavelength of the energy band gap is shifted towards red when the amount of the cadmium concentration increases. Complex impedance spectroscopy shows best ionic conductivity of $1.8 \pm 0.7 \times 10^{-5} S/cm$ for PEO-Chitosan. Furthermore, the thin films of zinc oxide, cadmium oxide and mixed zinc-cadmium oxide and polymer were assembled to form photovoltaic cells and are characterized using solar simulator. The J-V characteristic curve of an optimized cell ITO/Zn_{0.6}Cd_{0.4}O/PEO/ITO shows the efficiency of 1.702%.

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