CHAPTER - V

SUMMARY AND CONCLUSIONS

Semiconductor liquid junction devices have been used not only for direct conversion into electricity but also for storage of energy in oxidized and reduced chemical species. Only few reports are available on semiconductor septum (SC-SEP) cells, because it is of the recent origin.

The conventional redox storage cells are well known. However, the solar energy storage with the help of semiconductor septum cells is new and most promising due to their inherent properties. The concept of Semiconductor Septum cell is based on modelling bilayer lipid membrane. In SC-SEP solar cells, the semiconductor separates two compartments containing different redox couples. These redox couples can either be oxidised or reduced under illumination. Such chemical species can be electrochemically discharged for production of electricity. Solar energy can be stored in the form of a transportable form a fuel, such as H_2 by photoelectrolysis. The H_2 can later be burnt in fuel cells etc. to generate electrical power. SC-SEP solar cells can also be used for H_2 production.

The performance of these septum cells depends on semiconductor septum, variety of redox electrolytes and contacting electrodes. Semiconductor septum can be produced by using different techniques like spray pyrolysis, slurry painitng, electrodeposition etc. But electrodeposition is an attractive method for preparation of thin film, the main advantage being the easy control of growth rate through electrical quantities. Several promising materials are being developed at various research laboratories in view of their extensive use in photoelectrochemical solar cells. Low band gap material like CdSe, CdTe respond to major fraction of visible spectrum. In the present investigation the semiconductor septum cells are formed with CdSe films formed on metallic substrates and results are discussed in the dissertation. It consists of five chapters.

In first chapter, energy resources and purpose of dissertation are described. Types of solar cells and their electrical characteristics, semiconductor-liquid junction solar cells, semiconductor septum solar cells and modelling of solar cells are discussed in chapter second. In the third chapter synthesis of large size CdSe films on stainless steel, construction of SC-SEP solar cells and their working are described. Properties of Sc-SEP solar cells, like charging-discharging behaviour of SC-SEP solar cells, corrosion of semiconductor septum cell formed with $FeCl_3$ electrolyte are also described. At the end of this chapter modelling of SC-SEP solar cells is described. The voltages and currents of series and parallel combinations of semiconductor septum solar cells are studied. The new type of SC-SEP cell called line semiconductor septum cell is designed and constructed and its use for hydrogen production is described in fourth chapter. The results are summarised in brief as follows :

In present investigation large size CdSe films have been prepared by electrodeposition technique, having all parameters optimized. The films electrodeposited onto stainless steel substrate at potential -0.65 V Vs SCE from bath (10 mM $CdSO_4$ + 10 mM SeO_2, pH = 2-3) are found to be of n-type. For deposition, same stainless steel was used as a counter electrode. It was observed that the films were very much sticky and uniform as compared to the films obtained by graphite as a counter electrode.

In order to understand the growth mechanism, the variation of current density with time was studied. The current density decreases with increasing time. The thickness of film increases with deposition time. The polarisation curve was recorded at room temperature of bath.

The CdSe films deposited at potential -0.65 V Vs SCE were annealed at 370°C for 30 minutes. After annealing, CdSe/Stainless steel contact is ohmic and it was observed that the films were more stable in polysulphide solution. Annealed films also showed greater PEC effect.

Micrographs show that the, films are uniform, dense and packed. The presence of sharp peaks in XRD pattern shows the film is polycrystalline in nature.

In semiconductor septum solar cells, different approaches have been carried out, where semiconductor electrode acts as photoanode as well as separator of two aqueous compartments. The semiconductor septum solar cell consisted of two compartments made up of plastic boxes with 10 cm X 8 cm area cut on their sides. The n-CdSe/Stainless steel septum electrode was then fixed between two compartments, by using adhesive cream Araldite. The glass was fitted on front side of the first compartment to illuminate the film. The capacity of each compartment was 500 c.c. The compartment adjacent to the tungsten halogen lamp (500 W) was filled with 1 M polysulphide (Na_2S-NaOH-S) solution in contact with n-CdSe film and kept constant throughout the experiment. The other compartment (dark) was filled with a redox couple like $FeCl_3$. The concentration of $FeCl_3$ was varied. The counter electrodes in both compartments were graphite plates. The area of graphite electrode in both the compartments was near about 120 cm^2.

Properties of semiconductor septum solar cell were studied. When only first compartment was filled with polysulphide solution, then photovoltage (V_{ph}) and photocurrent

(I_{ph}) were increased with increase in light intensity. Photocurrent also found to depend upon the area of film. When graphite was used as counter electrode in PEC cell, then photocurrent was 6.5 mA and when stainless steel was used, then it was 0.52 mA. Thus stainless steel is not suitable for PEC cell as counter electrode when substrate is stainless steel.

The cell voltage and currents of different semiconductor septum storage cells for different areas of semiconductor septum film and different concentration of $FeCl_3$ in compartment II were studied. The illumination intensity of light was 80 mW/cm^2. The magnitudes of voltage and current of semiconductor septum storage cell depend on (1) Adaptability of electrolyte/electrode (2) Difference in redox Fermi levels (3) Area of semiconductor septum and (4) Total nùmber of charges stored in compartments.

In order to understand the mechanism of charging we have studied variation of cell voltage with time during excitation of cell (Photocharge). The cell voltage rises in exponential fashion with time and after some time open circuit voltage is saturated. For 100 cm^2 area of film (septum), one of the cells showed that I_{sc} = 300 mA and V_{oc} = 1.00 volts. For 80 cm^2 area of the film I_{sc} = 200 mA and V_{oc} = 1 volts after charging for 1 hour.

For 1 M concentration of $FeCl_3$ in compartment II it was observed that I_{sc} = 200 mA and V_{oc} = 1 volts in one of the cells. For 0.5 M concentration of $FeCl_3$ V_{oc} = 0.7 volts and I_{sc} = 80 mA were observed and that for 0.1 M concentration of $FeCl_3$, V_{oc} = 0.6 volts and I_{sc} = 22 mA, after charging in 1 hour. Thus it is concluded that at high concentration, the current capacity is large. The current capacity of the cell decreases with decrease in concentration. It is attributed to the fact that, the availability of number of Fe^{3+} ions for the reduction reaction in compartment II. The increase in concentration increases the number of Fe^{3+} ions and therefore, more number of electrons generated in the semiconductor septum are utilised to convert Fe^{3+} into Fe^{2+}. Thus current capacity of the cell depends upon the concentration of electrolyte in compartment II.

Discharging characteristics were studied. Continuous power could be generated through an external load more than 4 hours. The power extracted from the cell was more for the cell with 1 M $FeCl_3$ and it decreased with decrease in concentration of $FeCl_3$.

Corrosion of semiconductor septum cell formed with $FeCl_3$ electrolyte was studied. The power extracted from the cell was more for higher concentration of $FeCl_3$ and it decreases with decrease in concentration of $FeCl_3$. However, it is found that as concentration of $FeCl_3$ increases, there starts the corrosion of semiconductor septum cell. At 1 M $FeCl_3$, the septum gets corroded and holes were observed on steel plate. This might be due to the fact that stainless steel contains Ni, Cr, Co and Fe, So when steel is in contact with $FeCl_3$, then there is a removal of Ni, Cr and Co from the steel and only Fe remains as it is. So holes are created. It we use iron instead of steel, then there might be no corrosion.

For number of electric devices, one needs different power supplies with certain voltages and current capacity. In view of this, we have studied series - parallel combination of semiconductor septum solar cells. In the study of series combination of the cells, when the two cells of semiconductor septum film area 100 cm^2 filled with 1 M polysulphide in compartment I and 1 M $FeCl_3$ in compartment II, were connected in series, then it was observed that V_{OC} = 1.73 volts and I_{sc} = 143 mA. The light emitting diode (LED) when connected across the electrodes of these two cells, it gets enlighted. This means that the current capacity of one cell is sufficient to operate light emitting diode.

The variation of voltage and current with 5 number of cells in series for different areas of semiconductor septum film and different concentration of $FeCl_3$ in compartment II were studied. It was observed that as number of cells in series increases, the voltage increases and current nearly remains constant. The cell voltage decreases as concentration of $FeCl_3$ decreases.

For getting higher current we have to connect the number of cells in parallel. In view of this, we have studied, the parallel combination of cells. It was observed that, as the number of cells in parallel increases, the current increases and voltage nearly remains constant. It is seen that, for higher concentration of $FeCl_3$ in compartment II, the current capacity is high.

We have studied the series - parallel combination of SC-SEP solar cells by different number of ways. When three cells were in series and another three cells in series and connecting these two combination in parallel, it was observed that, V_{OC} = 2.50 volts and I_{sc} = 280 mA.

When the cells were connected in series - parallel combination then it was observed that the results were of smaller values than the expected one. This may be due to the charge transfer reactions between the number of cells and internal losses of the cells.

By using number of semiconductor septum solar cells in series - parallel combination one can obtain desired power supply.

The SC-SEP solar cell is also used for hydrogen production by photoelectrolysis. The hydrogen can later be burnt in fuel cells etc. to generate electrical power. In view of this we have designed and constructed new type of cell called line semiconductor septum solar cell for high intensity by using line concentrator and studied for hydrogen production. The production of H_2 mostly depends on intensity of light. The compartment I was filled with 0.2 M K_4 $Fe(CN)_6$ + 0.01 M K_3 $Fe(CN)_6$ + 0.1 M KOH solution and compartment II was filled with artificial seawater. The pH of electrolyte was found to change with H_2 production under electrolytic static conditions. However, continuous production of H_2 was observed under electrolytic dynamic conditions.

In conclusion we have succeeded in designing, fabricating and testing a new type of semiconductor septum solar cell both for production of electrical energy and also storage in the form of redox species as well as Hydrogen gas.