CHAPTER - 5

SUMMARY AND CONCLUSIONS

In recent years semiconductor septum electrochemical photovoltaic cells (SC-SEP) have been attracted due to their applications for solar energy storage in the form of electrical energy or a transportable fuel, such as hydrogen. In light of literature survey, it is found that there are many reports available on electrochemical photovoltaic cells formed with CdS, ZnS, n-CdSe etc. and few reports are available on semiconductor septum cell as it is of recent origin. The convensional redox storage cells are well known. However, the hydrogen production with help of semiconductor septum cell is new and most promising due to their inherent properties. The concept of semiconductor septum solar cell is based on modeling of natural photosynthetic systems with a pigmented bilayer lipid membrane. The performance of these septum cells depends on semiconductor septum, redox electrolyte and contacting electrodes.

The large band gap materials such as TiO_2, ZnO, $SrTiO_3$ etc. are found to be stable but do not respond to visible light, while relatively low band gap materials like n-CdSe and CdTe respond to major fraction of visible spectrum. The semiconductor septum can be produced by using

different techniques like spray pyrolysis, slurry painting, electrodeposition etc. But electrodeposition is an attractive method for preparation of thin films, the main advantage being the easy control growth rate through electrical quantities.

In present investigation, attempts have been made to deposit uniform large area n-CdSe films with the use of electrodeposition technique. These films were deposited on stainless steel substrate and used as septums in SC-SEP cells. We have studied hydrogen production with semiconductor septum solar cells at static electrolytic conditions for various parameters viz. SC-SEP area, volume of electrolyte intensity of illumination etc. We have also studied hydrogen production at electrolytic dynamic conditions for continuous and interrupted flow of electrolyte. The charging and discharging characteristics are also studied.

The different phases of work is described in the four chapters. In chapter first energy resources, hydrogen production, septum cells and purpose of dissertations are described in brief. The chapter II introduces the theoretical background of electrochemistry and the energy conversion by semiconductor septum cells which is based on existing literature. Third chapter reports on the

preparative parameters of electrodeposited large area n-CdSe thin films and their use as septum electrode in fabrication of SC-SEP solar cells. Chapter IV describes hydrogen production with semiconductor septum solar cell by using artificial sea water at electrolytic static and dynamic conditions. It also describes charging and discharging behaviour SE-SEP solar cell.

The results are summarised in brief as follows :

Cadmium selenide films of size 90 cm^2 were electrodeposited on stainless steel substrates under d.c. potentiostatic conditions. Three electrode system was employed and potentials were measured with respect to saturated calomel electrode (SCE). The mirror polished stainless steel substrates are suitable to electrodeposit n-CdSe films. Substrate celaning affects the adherence, smoothness, brightness and uniformity of films. The deposition potential -0.65 V vs SCE was determined from polarization curve. These electrodeposited films in bath (10 mM $CdSO_4$, $8H_2$ + 10 mM SeO_2, pH 2 to 3), at potential -0.65 V vs SCE, for 60 minutes deposition time were sticky and uniform. The solution prepared before 12 hours for electrodeposition of films was more suitable than just prepared solution to get better films. In order to understand growth mechanism; the variation of current density with time was studied.

It was observed that n-CdSe films electrodeposited by using stainless steel as counter electrode are more sticky and uniform than those prepared by using graphite electrode. The thickness of the electrodeposited n-CdSe film was of the order of 1.79 μm.

It was found that annealed films were more stable and showed more PEC effect. Micrograph shows that n-CdSe films electrodeposited at potential -0.65 V vs SCE are dense, uniform and packed arrangement of grains. Annealed films showed more improved structure. The presence of sharp peaks in XRD diffraction pattern shows, that the n-CdSe film is polycrystalline in nature. The observed 'd', values are well matched with standard 'd', values (from ASTM data) of hexagonal structure of n-CdSe film.

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 cell consisted of two compartments made of transparent plastic and n-CdSe|stainless steel septum electrode was fixed between two compartments. Graphite and lead electrodes were used as contacting electrodes in the two compartments.

In a semiconductor septum electrochemical photovoltaic cell (SC-SEP) hydrogen production is possible, under short circuit condition by photolysis of sea water using solar energy. When only first compartment was filled with polysulphide, then photocurrent was found to increase with intensity. The photocurrent also found to depend on area of n-CdSe film.

At static electrolytic condition 4.5 cc hydrogen production was observed in time about three hours for following SC-SEP cell arrangement.

Graphite Electrode	0.2 M $K_4Fe(CN)_6$ 0.01 M $K_3Fe(CN)_6$ 1 M KOH	n-CdSe film	st. steel	Artificial sea water	Pb

When semiconductor septum cell was operated under open circuit condition no hydrogen production was observed.

The rate of hydrogen production was found to increase by increasing intensity of illumination. Hydrogen production was also studied for different semiconductor septum area of films in two cells. The rate of hydrogen production increases with increasing semiconductor septum area of film. It was also observed that maximum quantity of hydrogen depends on volume of electrolytes in two compartments of semiconductor septum cell. The variation of short circuit current across contacting electrodes was

studied. It was observed that short circuit current decreases with time during hydrogen production. This decrease in current may be due to the fact that hydrogen bubbles resulted to stop flow of electrons.

The pH of the solution in second compartment containing artificial sea Water was measured before and after hydrogen gas collection and found to change from 7.1 to 7.4. The change of pH is attributed to the increase of $O\bar{H}$ ion concentration in the second compartment.

To avoid increase of $O\bar{H}$ ions concentration in second compartment, hydrogen production was studied at electrolytic dynamic condition with a following system,

Graphite|1M,3S|n-CdSe|St.-steel|Artificial sea water|Pb

The continuous flow of electrolyte method is not suitable for continuous hydrogen production because some of the ions and part of hydrogen gas produced flow through electrolyte from outlet of second compartment of SC-SEP cell. For continuous hydrogen production, it is necessary to stabilize pH of the solution in the second compartment of cell. This was done by changing electrolytes in compartments of SC-SEP cell for three different stages. The continuous hydrogen production was observed by making arrangement of interrupted flow of electrolytes.

The SC-SEP cell can also store electrical energy, above some threshold. The highest value of which depends upon difference between the redox potential of system. When 1M $FeCl_3$ was filled in second compartment of the cell, the open circuit voltage after charging cell for one hour at intensity 100 mW/cm^2 was 0.87 volt. The discharging of same cell across 1 K Ω was also studied. The continuous power could be generated through external load for time more than three hours.

From above information, it is seen that in SC-SEP cells solar energy can be stored both in the forms of electrical energy or transportable fuel hydrogen. Continuous hydrogen production is possible at electrolytic dynamic conditions for interrupted flow of electrolyte.