CHAPTER I

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Introduction

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1.1 Semiconductor Heterojunction and Solar Energy Conversion

Solid state energy conversion is based on the concept of junction. The junction can be defined as the contact between any two dissimilar things. As per the states of matter existing in the nature, i.e. solid, gas and liquid, one can have the junction between solid-solid, solid-liquid, solid-gas, liquid-gas etc. The first two categories of the junctions are stable one and have great importance in respect of their applications in energy conversion devices. Let us consider solid-solid junction.

When the junction is looked at through the physical approach it is classified as, abrupt junction and graded junction. In case of abrupt junction the width of the junction is very small of the order of few angstroms (A^{o}), while in the case of graded junction the atoms from one material are diffused into the second material across the junction and vice versa, as a result there is no sharp boundry at the junction.

When one consider junction through the materialistic aspects, the junction be divided into two groups namely, Homojunction and Heterojunction.

The example of homojunction is P-Si-n-Si or P-Ge-n-Ge. In the case of heterojunction the materials on both sides of the junction are different. The example of heterojunction is n-CdS-P-Cu_2S.

From the general definition of the junction one can form the junction between any two dissimilar things; however for constructing the semiconductor heterojunction one has to be particular about some criteria while selecting the semiconductor for the junction and these are namely,

1) Lattice mismatch
2) Thermal mismatch
3) Interdiffusion.

Lattice Mismatch : The two semiconductors with the lattice constant a_1 and a_2 are brought together for the junction and if a_2 a_1 then the lattice mismatch is defined as

$$l.m = \frac{a_2 - a_1}{(a_2 + a_1)/2} = \frac{2(a_2 - a_1)}{(a_2 + a_1)}$$

For the ideal heterojunction lattice mismatch should be zero. Any deviation from the value of lattice mismatch from zero, gives rise to the presence of defects of the interface. For the better heterojunction properties, the presence of defects at the interface should be avoided.

Thermal Mismatch : If the two semiconductors have different thermal expansion coefficient, i.e. if there is a large thermal mismatch then the heterojunction between these two semiconductor leads to the formation of cracks at their interface. Hence there must be minimum thermal mismatch between the two semiconductors which are used for heterojunction.

iii) Interdiffusion : Since the junctions are fabricated at high temperature the atoms of the semiconductor from one side of junction are diffused into the second semiconductor on the other side and vice versa. If the diffusion coefficient of the two semiconductors are large then there will be intermixing of the two semiconductor forming an alloy instead of a heterojunction. Thus the diffusion coefficient of the two semiconductors must be smaller.

Solar Energy Conversion : Principle of Solar Cell

Solar cell is the semiconductor device which converts the radient energy into the form of electrical energy. The radiant energy is given by the relation $E = h\nu$. The electrical energy device consists of the source and the sink of electrons. When source and sink are connected together through the external circuit, there flows the current. So the requirement is to produce source of electrons and holes at the consumption of radiant energy. This can be done with a semiconductor. When photon of energy, $h\nu$ greater than the band gap energy, Eg of a semiconductor, is absorbed, a pair of electron and hole is generated. However the electron with negative and hole with positive charge attract and recombine immediately. As a result, though the electrons and holes are generated within a single piece of semiconductor by the absorption of radiant energy one cannot get externally the electron to flow.

However, if one creates a situation, wherein the electrons and holes are immediately separated, produces an electricity. This is done with junction device.

When the semiconductor junction is formed, due to the transport of charges across the junction to set the equilli-brium i.e. to make the fermi levels at equal energy level, the doners are ionized at the interface within the n-type semiconductor and acceptors are ionized at the interface within p type semiconductor. This gives rise to a local field, also called as built in potential V_o. When light of energy $h\nu \cdot Eg$ is made to incident with this interfacial layer the pairs of electron and hole are generated and are separated due to the influence of local electric field as shown in fig.(1.1).The n-type side of a junction acts as a source of electrons while the P-type, as a sink of electrons and when these two sides are connected through the external circuit, the current flows through external circuit.

1.2 Survey of Literature on CdS, PbS and their Heterojunctions

Cadmium sulphide has received considerable attention in recent years due to its potential applications in CdS/Cu_2S solar cells[1-5]; similarly the interface between a Cd-chalco-genide semiconductor and an aquous polysulphide electrolyte is one of the most extensively studied photovoltaic cells for

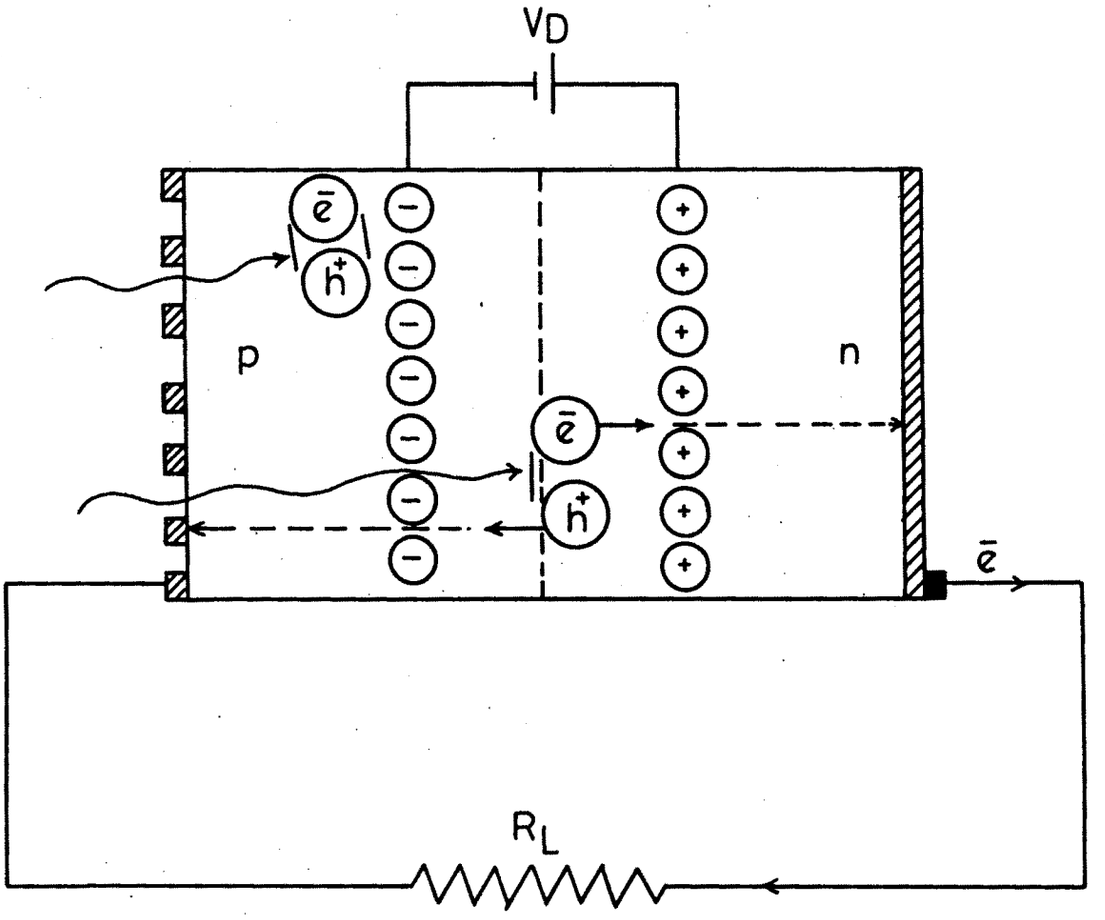

Fig. 1·1 p-n junction with influence of local electric field.

the direct conversion of solar irradiation into electricity[6-14]. ECPV cell using n-CdS crystal as a photoanode, doped SnO_2 counter electrode and Fe $(CN)_6^{3-/4-}$ redox couple with 5% efficiency was reported first time by Gerischer[15]. Similar results were reported by Anderson and Chou[16], later on; on CdS photoanode. Studies have been made on films prepared by various techniques such as vacuum deposition, sintering, chemical bath deposition, spray pyrolysis and recently on solution-gas interface technique. To improve the conductivity of CdS film and finally the efficiency of ECPV cell, various dopants such as Al, In, Bi are tried and reported[17-20] ECPV cells with configuration CdS/NaOH-S-Na_2S/C or Pt are studied and their results are reported.[21-22].

Lead sulphide is one of the most useful semiconductor to form heterojunctions because of their use as near and medium IR detectors. Thin uniform films of lead sulphide can be prepared by various methods. Recently T.K.Chaudhari and et al developed a new technique for preparing lead sulphide thin films.[23-24] Many heterojunction pairs have been fabricated and studied[1-5,25-31] which includes CdS-Cu_2S, CdS-Si, CdS-SiC, CdS-Ge, CdS-ZnS, CdS-ZnTe. Ge-PbS heterojunction was also studied.[32] For the special use in near and medium IR detectors, Watanabe and Mita[33,34] fabricated CdS-PbS heterojunction in which PbS films were grown epitaxially on CdS single crystal. The CdS-PbS heterojunctions

have been fabricated by Pawar and et al by depositing polycrystalline films of PbS and CdS and results of photovoltaic effect have been reported.[35]

1.3 Statement of the Problem

The photovoltaic conversion is direct energy conversion process and ideally, should be efficient. In this investigation an attempt will be made for a study of electrical and optical properties of as prepared and vacuum annealed CdS and PbS films and their heterojunctions. The study is planned as follows :

1) The chemical bath deposition technique will be used to prepare good crystalline CdS films.

2) Freshly prepared CdS films will be annealed in vacuum (10^{-3} torr) at 200°C temp. for one hour.

3) As prepared and vacuum annealed CdS films will then be used to study the microstructure, optical absorption and electrical resistivity of the material.

4) The ECPV cell will then be formed with configuration CdS/NaOH-S-Na_2S/C. Both as prepared and vacuum annealed CdS films are used as a photoanode in the ECPV cell to examine the effect of vacuum annealing on efficiency of the ECPV cell.

5) CdS-PbS heterojunction will then be formed by deposition of PbS on CdS film by chemical bath deposition technique.

6) Freshly prepared CdS-PbS heterojunctions will then be examined to study the efficiency of S-S heterojunction solar cell.

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