Solar Cell : The Mechanism

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Abstract: A solar cell or photovoltaic cell is electrical device that converts light energy into electricity brought major revolution in reducing power consumption. The light is absorbed from sunlight and electricity is produced by the photovoltaic effect. The paper reviews the functioning solar cell and the advancements made to them in terms of material and efficiency
Keyword: solar cell; photovoltaics; energy

I. INTRODUCTION

Solar cells and photodetectors are devices that convert an optical input into current. A solar cell is an example of a photovoltaic device, i.e., a device that generates voltage when exposed to light.The functioning of a solar cell is similar to the photodiode (photodetector). It is a photodiode that is unbiased and connected to a load (impedance) but the three qualitative differences between a solar cell and photo detector are : a photodiode works on a narrow range of wavelength while solar cells need to work over a broad spectral range (solar spectrum), Solar cells are typically wide area devices to maximize exposure, in photodiodes the metric is quantum efficiency, which defines the signal to noise ratio, while for solar cells, it is the power conversion efficiency, which is the power delivered per incident solar energy. Usually, solar cells and the external load they are connected to are designed to maximize the delivered power.

II. HISTORY

It has now been 175 years since 1839 when Alexandre Edmond Becquerel observes the photovoltaic (PV) effect via an electrode in a conductive solution exposed to light [1]. It is instructive to look at the history of PV cells since that time because there are lessons to be learned that can provide guidance for the future development of PV cells. These 175 years can be conveniently divided into 6 time periods beginning with the discovery years from 1839 to 1904. Table gives the most significant events during this first period. In 1877, Adams and Day observed the PV effect in solidified selenium and in 1904[3] Hallahs made a semiconductor-junction solar cell with copper & copper oxide. However, this period was just a discovery period without any real understanding of the science behind the operation of these first PV devices. A theoretical foundation for PV device operation and potential improvements was formulated in the second phase of the history of PV in the period from 1905 to 1950. Key events in this period were Einstein's photon theory [4], the adaptation of the Kochanski crystal growth method for single crystal silicon and germanium growth [5] and the development of band theory for high purity single crystal semiconductors [6, 7]. The PV cell theory developed emphasized the importance of high purity single crystal semiconductors for high efficiency solar cells. These developments laid the foundations for the 3rd phase of PV device development.

III. SOLAR CELL WORKING PRINCIPLE

A simple solar cell is a pn junction diode. The schematic of the device is shown in figure1. The n region is heavily doped and thin so that the light can penetrate through it easily. The p region is lightly doped so that most of the depletion region lies in the p side. Radiation is absorbed in the depletion region and produces electrons and holes. The penetration depends on the wave- length and the absorption coefficient increases as the wavelength decreases. Electron hole pairs (EHPs) are mainly created in the depletion region and due to the built-in potential and electric field, electrons move to the n region and the holes to the p region. When an external load is applied, the excess electrons travel through the load to recombine with the excess holes. Electrons and holes are also generated with the p and n regions, as seen from figure 2. Photogenerated carrier, on absorption of light in solar cell w is the width of the depletion region, while Lh and Le are minority carrier diffusion lengths in the n and p regions. The amount of absorption reduces with depth and hence the depletion region must be close to the surface to maximize absorption. This is achieved by having a thin n region. .The shorter wavelength (higher absorption coefficient) are absorbed in the n region and the longer wavelengths are absorbed in the bulk of the p region. Some of the EHPs generated in these regions can also contribute to the current

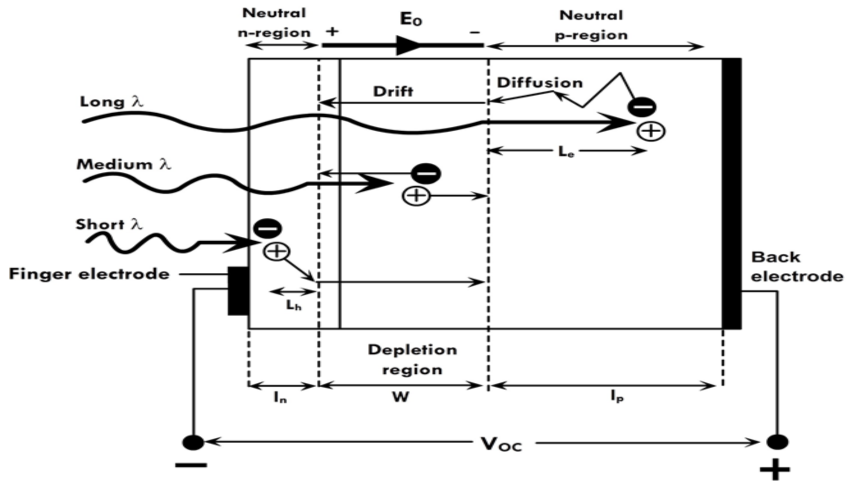

Figure1 : Principle of operation of a pn junction solar cell.

Figure3 shows Finger electrodes on a pn junction solar cell. The design consists of a single bus electrode for carrying current and finger electrodes that are thin enough so that sufficient light can be absorbed by the solar cell. Conventional solar cells are made of Si single crystal and have an efficiency of around 22-24%, while polycrystalline Si cells have an efficiency of 18%. A schematic representation of such a cell is shown in figure . The efficiency of the solar cell depends on the band gap of the material and this is shown in figure Polycrystalline solar cells are cheaper to manufacture but has lower efficiency since the microstructure introduces defects in the material that can trap carriers.

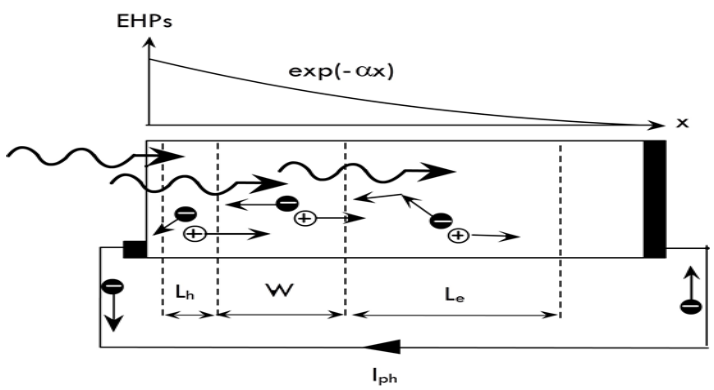

Figure2 : Photogenerated carriers in a solar cell due to absorption of light.

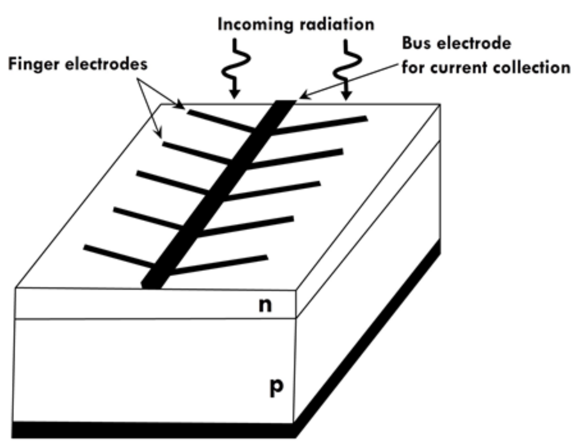

Figure3 : Finger electrodes on a pn junction solar cell.

IV. SOLAR CELL MATERIALS AND EFFICIENCY

Amorphous solar cells have an even lower efficiency but can be grown directly on glass substrates by techniques like sputtering so that the overall cost of manufacturing is lowered. There are also design improvements in the solar cell that can enhance the efficiency. PERL (passi- vated emitter rear locally diffused) cells, have an efficiency of 24% due to the inverted pyramid structure etched on the surface that enhances absorption The data is tabulated in Table 1

V. CONCLUSION

Solar energy is clearly part of the solution to the problem of dwindling fossil-fuel reserves. It's increasingly cheap; it's the target of huge quantities of investment and entrepreneurship, thanks to innovations like CSP (Concentrating Solar Power). But if you flinch at the idea of a world dominated by flat panels and vaguely sinister solar receiver towers, take heart: many designers are looking at the natural world for inspiration.

Table1: Some common solar cell materials and their characteristics.

Semi- conductor	Eg(eV)	Voc(V)	Jsc (mAcm−2)	η(%)
Si, single Crystal	1.1	0.5-0.7	42	16-24
Si, poly- crys- talline	1.1	0.5-0.65	38	12-19
GaAs, single crystal	1.42	1.02	28	24-25
GaAlAs/GaAs, tandem	1.9	1.03	27.9	25
GaInP/GaAs, tandem	2.5	2.5	14	25-30
CdTe, thin film	2.42	0.84	26	15-16
InP, single crystal	1.34	0.87	29	21-22

VI .REFERENCES

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