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SMULATION OF PHOTOVOLTAIC SYSTEM

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" It is hereby declared that this thesis is the effort of my own work and those that are not the effort my own have been clearly acknowledge. "

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Date : 18/11/2005 ……………………..

For my beloved father and mother

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ABSTRACT

Photovoltaic uses sun to generate electricity and it involves the conversion of sunlight into direct current (DC) electricity through the use of thin layers of materials known as semiconductors. My project is to build a simulation using "Macromedia Flash". The objectives of this project are to show the principle of photovoltaic system and for learning purposes of photovoltaic system using interactive multimedia. The scopes of this project are to show generating electricity using photovoltaic system, producing p-type and n-type using silicon semiconductor, creation of pn junction and simulation application to show the principle of photovoltaic system.

ABSTRAK

Photovoltaic digunakan untuk menghasilkan elektrik dan ianya melibatkan pertukaran daripada cahaya matahari kepada arus elektrik menerusi penggunaan satu lapisan nipis yang dikenali sebagai separuh pengalir. Projek saya adalah untuk membangunkan simulasi menggunakan perisian "Macromedia Flash". Objektif projek ini adalah untuk menerangkan mengenai prinsip sistem *photovoltaic* dan untuk pembelajaran mengenai sistem *photovoltaic* menggunakan perisian. Skop projek adalah untuk menunjukkan penghasilan elektrik menggunakan sistem *photovoltaic*, penghasilan bahan p dan n menggunakan bahan separa pengalir, pembentukan simpang pn dan aplikasi perisian untuk menunjukkan prinsip system *photovoltaic*.

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CHAPTER 1

INTRODUCTION

Currently electricity power is generated by using one of the following method, hydroelectric, stem, gas and renewable energy. Another alternative to generate electricity is using photovoltaic system. Photovoltaic is the direct conversion of sunlight into electricity with no intervening heat engine. The conversion process is based on the photoelectric effect. The photoelectric effect describes the release of positive and negative charge carriers in a solid state when light strikes its surface. The energy from the sun can serve many purposes.

One of them is to generate electricity (refer to Figure 1.1). This is call solar electricity. Before generate electricity using photovoltaic system the principle of the solar panel must be known. My project is to build a simulation model to show the working principle of generating electricity using photovoltaic technology. Photovoltaic system usually used silicon semiconductor element, although we may have some other elements, such as germanium. Semiconductors are materials that become electrically conductive when it supplied with light or heat. Semiconductor operate as insulators at low temperatures. Over 95% of all the solar cells produced worldwide are composed of the semiconductor material Silicon (Si). Firstly the suitable element to produce p-type and n-type semiconductor. For example we take silicon semiconductor to produce p-type and n-type semiconductor. The choices of the donor element to form an n-type element, and the acceptor element to form a p-type element also plays an important role in producing DC electricity when the pn-junction is formed. "Doping" is the intentional introduction of chemical elements, with which one can obtain a surplus of either positive charge carriers (p-conducting semiconductor layer) or negative charge carriers (n-conducting semiconductor layer) from the semiconductor material. If two differently contaminated semiconductor layers are combined, then a so-called p-n-junction results on the boundary of the layers.

The outputs of the study are to develop a simulation application to show the principle of photovoltaic system, and to study the detail of pn-junction principles in generating DC electricity. The following are the contain of my project. In chapter 1, I will briefly about my project. My project is simulation for photovoltaic system. Also include in this chapter is the objective of my project. In chapter 2 it is about literature review on my topic. In this chapter, I will explain the works that have been done from my literature search. The following chapter is methodology. In methodology, I will explain the step of doing my project. In chapter 4 it is about analysis on the design aspects. From the information that I get, I will analyze it to apply in design. Next in chapter 4 is the result of my project. In Chapter 6, I will conclude what are the work that I have done and future expectation of my project.

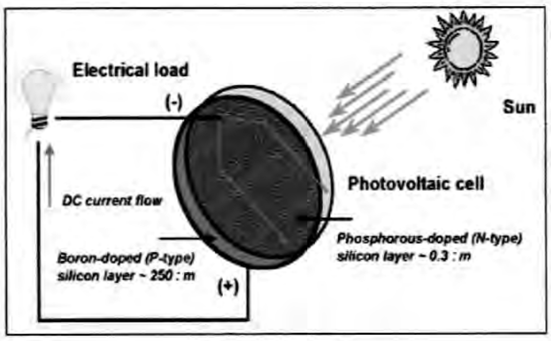

Figure 1.1 : Diagram of photovoltaic cell [1]

1.1 Objective Of Project

The main purpose of this project is to develop a simulation application to show the principle of the photovoltaic system. During this process, this project must also determine the solar cell material that is suitable for the solar panel. Apart from that, the suitable energy gap between metal, semiconductor or insulator for produce current is determined depends on the photovoltaic principle. This project must also determine the electron movement in the pn-junction that produce current.

1.2 Scope

Scope of my project is to build simulation to show working principle of generating electricity using photovoltaic technology. Therefore principle of producing p-type and n-type semiconductor must be known. On the other hand the scope of the project is to study the phenomena of producing electron-free from the pn-junction. After that is to develop simulation application using "Macromedia Flash" to show the principle of photovoltaic system.

CHAPTER 2

LITERATURE REVIEW

2.1 Converting Photons To Electrons

Photovoltaic convert sunlight directly into electricity. Once used almost exclusively in space, photovoltaic are used more and more in less exotic ways.

Photovoltaic (PV) cells are made of special materials called semiconductors such as silicon, which is currently the most commonly used. Basically, when light strikes the cell, a certain portion of it is absorbed within the semiconductor material. This means that the energy of the absorbed light is transferred to the semiconductor. The energy knocks electrons loose, allowing them to flow freely. PV cells also all have one or more electric fields that act to force electrons freed by light absorption to flow in a certain direction. This flow of electrons is a current, and by placing metal contacts on the top and bottom of the PV cell. For example, the current can power a calculator. This current, together with the cell's voltage (which is a result of its built-in electric field or fields), defines the power (or wattage) that the solar cell can produce.

A material in which conduction occurs due to electron excitation is called an intrinsic semiconductor. Conducting in an intrinsic semiconductor is caused by electron excitation. Each electron moving to the conduction band leaves behind a vacant state called the "hole" in the valence band. The hole behaves like a particle of positive charge. Thus, each thermal excitation of an electron liberates not one, but two, charge carries. The concept of a hole in the valence band is similar to a vacancy in a crystal. The motion of a hole to the right is equivalent to an electron moving to the left, since negative charge has been transferred to the left. This is called " hole conduction". In an intrinsic semiconductor, the number of holes is equal to the number of conduction electrons. Silicon (Si) and germanium (Ge) are two of the most important semi conducting elements, although boron (B), tellurium (Te) and some allotropes of tin (Sn) are also intrinsically semi conducting [2].

There are two main semiconductor material :
Intrinsic - where the semiconductor properties of the material occur naturally.
Extrinsic – they semiconductor properties of the material are manufactured
by us to make the material behave in the manner which we require.

Usually semiconductor use intrinsic compare to extrinsic because extrinsic semiconductor is a material with large band gap which would be insulator.
Intrinsic semiconductor are those materials with relatively small band gaps of typically less than 0.5 eV. In this cases, a number of electrons can be thermally stimulated across the band gap at room temperature 27° C (300K. Once in the conduction band these electrons contribute to the electrical conductivity, as do the 'holes' which are left behind in the valence band [3].

2.2 Types Of Solar Cell

One can distinguish three cell types according to the type of crystal: monocrystalline, polycrystalline and amorphous(refer to Figure 2.1) . To produce a monocrystalline silicon cell, absolutely pure semi conducting material is necessary. Monocrystalline rods are extracted from melted silicon and then sawed into thin plates. This production process guarantees a relatively high level of efficiency. The production of polycrystalline cells is more cost-efficient. In this process, liquid silicon is poured into blocks that are subsequently sawed into plates. During solidification of the material, crystal structures of varying sizes are formed, at whose borders defects emerge. As a result of this crystal defect, the solar cell is less efficient. Polycrystalline thin films with specific discussion of copper indium diselenide (CIS) cadmium telluride (CdTe), and thin-film silicon.

If a silicon film is deposited on glass or another substrate material, this is a so-called amorphous or thin layer cell. The layer thickness amounts to less than 1µm (thickness of a human hair: 50-100 µm), so the production costs are lower due to the low material costs. However, the efficiency of amorphous cells is much lower than that of the other two cell types (refer to Table 2.1) . Because of this, they are primarily used in low power equipment (watches, pocket calculators) or as facade elements[2].

Material	Level of efficiency in % Lab	Level of efficiency in % Production
Monocrystalline Silicon	approx. 24	14 to17
Polycrystalline Silicon	approx. 18	13 to15
Amorphous Silicon	approx. 13	5 to7

Table 2.1 : Efficiency of The Material

Single Crystalline Solar Cell | Polycrystalline Solar Cell | Amorphous Solar Cell

Figure 2.1: Types of Solar Cell

2.3 Silicon

Silicon has some special chemical properties, especially in its crystalline form. An atom of silicon has 14 electrons, arranged in three different shells. The first two shells, those closest to the center, are completely full. The outer shell, however, is only half full, having only four electrons. A silicon atom will always look for ways to fill up its last shell (which would like to have eight electrons). To do this, it will share electrons with four of its neighbor silicon atoms. It's like every atom holds hands with its neighbors, except that in this case, each atom has four hands joined to four neighbors. That's what forms the crystalline structure, and that structure turns out to be important to this type of PV cell.

Pure silicon is a poor conductor of electricity because none of its electrons are free to move about, as electrons are in good conductors such as copper. Instead, the electrons are all locked in the crystalline structure. The silicon in a solar cell is modified slightly so that it will work as a solar cell [4].

2.3.1 Silicon in Solar Cells

A solar cell has silicon with impurities. Other atoms mixed in with the silicon atoms, changing the way things work a bit. These impurities are actually put there on purpose. Consider silicon with an atom of phosphorous here and there, maybe one for every million silicon atoms. Phosphorous has five electrons in its outer shell. It still bonds with its silicon neighbor atoms, but in a sense, the phosphorous has one electron that doesn't have anyone to hold hands with. It doesn't form part of a bond, but there is a positive proton in the phosphorous nucleus holding it in place.

When energy is added to pure silicon, for example in the form of heat, it can cause a few electrons to break free of their bonds and leave their atoms. A hole is left behind in each case. These electrons then wander randomly around the crystalline lattice looking for another hole to fall into. These electrons are called free carriers, and can carry electrical current. There are so few of them in pure silicon, however, that they aren't very useful. Impure silicon with phosphorous atoms mixed in is a different story. It turns out that it takes a lot less energy to knock loose one of "extra" phosphorous electrons because they aren't tied up in a bond their neighbors aren't holding them back. As a result, most of these electrons do break free, and have a lot more free carriers than we have in pure silicon. The process of adding impurities on purpose is called doping, and when doped with phosphorous, the resulting silicon is called N-type ("n" for negative) because of the prevalence of free electrons. N-type doped silicon is a much better conductor than pure silicon is. Actually, only part of our solar cell is N-type. The other part is doped with boron, which has only three electrons in its outer shell instead of four, to become P-type silicon. Instead of having free electrons, P-type silicon ("p" for positive) has free holes. Holes really are just the absence of electrons, so they carry the opposite (positive) charge. They move around just like electrons do [4].

For my project I take silicon for example because silicon is more suitable high-power devices than germanium and it can be used at much higher temperatures.

Semiconductor materials are poor conductor under normal condition. In order to separate the electron pair bonds and provide free electrons for electrical conduction, it would be necessary to apply high temperatures or strong electric fields.

Solar cells are composed of various semi conducting materials. Semiconductors are materials, which become electrically conductive when supplied with light or heat, but which operate as insulators at low temperatures. Over 95% of all the solar cells produced worldwide are composed of the semiconductor material Silicon (Si). As the second most abundant element in earth's crust, silicon has the advantage, of being available in sufficient quantities, and additionally processing the material does not burden the environment.

To produce a solar cell, the semiconductor is contaminated or "doped". "Doping" is the intentional introduction of chemical elements, with which one can obtain a surplus of either positive charge carriers (p-conducting semiconductor layer) or negative charge carriers (n-conducting semiconductor layer) from the semiconductor material. If two differently contaminated semiconductor layers are combined, then a so-called p-n-junction results on the boundary of the layers (refer to Figure 2.2) .

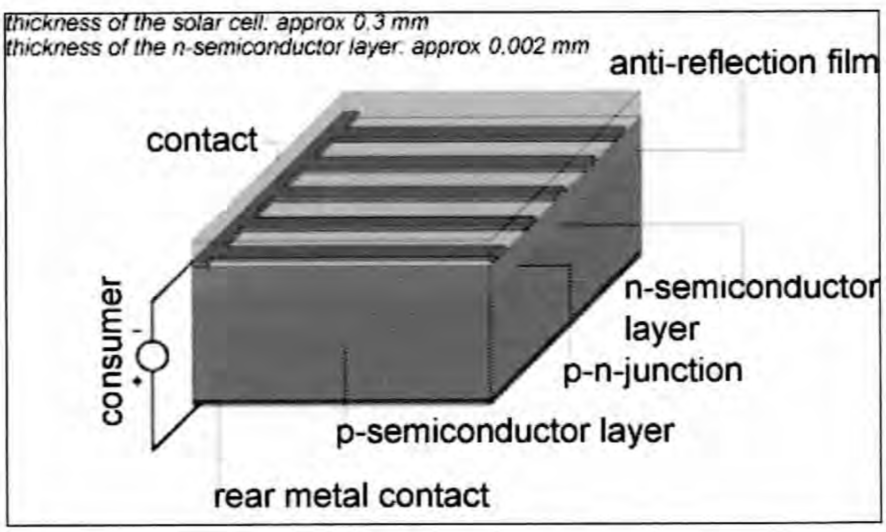

Figure 2.2 : Construction of Solar Panel [4]

At this junction, an interior electric field is built up which leads to the separation of the charge carriers that are released by light. Through metal contacts, an electric charge can be tapped. If the outer circuit is closed, meaning a consumer is connected, then direct current flows. Silicon cells are approximately 10 cm by 10 cm large (recently also 15 cm by 15 cm). A transparent anti-reflection film protects the cell and decreases reflective loss on the cell surface.

2.3.2 Characteristics of Solar Cell.

The usable voltage from solar cells depends on the semiconductor material. In silicon it amounts to approximately 0.5 V. Terminal voltage is only weakly dependent on light radiation, while the current intensity increases with higher luminosity. A 100 cm^2 silicon cell, for example, reaches a maximum current intensity of approximately 2 A when radiated by 1000 W/m^2 (refer to Figure 2.3) .

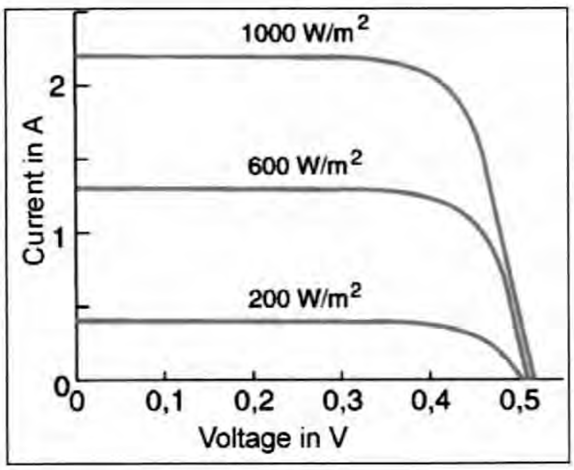

Figure 2.3 : Characteristic Of a Solar Panel

The output (product of electricity and voltage) of a solar cell is temperature dependent. Higher cell temperatures lead to lower output, and hence to lower