Fuzzy Interpretation of Absorption in Solar Cells

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Abstract

This paper caters feed for the issue of ***'Energy Conservation'*** taking into consideration the ideology of enhancing the availability and the utility of 'Non-Conventional' energy resources, as this is the medium the future globe ought to dominantly depend upon. The solar energy identified as the one in sustaining the required features of energy conservation is taken as the key factor of whose industrial element is the solar cell. This paper deals with the quanta factor of sun light on to a solar cell which is termed as the absorption to its proportionate current density generated. For this study the fuzzy interpretation is used on the various generation solar cells. The cut factors of the solar cells are fuzzyfied and analyzed with the absorption rate to predict the current density generation.

Keywords: Energy, Solar cells, Absorption, Reflectivity

Introduction

The term "solar energy" refers to a wide variety of techniques for using the energy available as sunlight. The global potential for solar energy is huge, since the amount of energy that reaches the earth's surface every year exceeds the total energy consumption by roughly a factor of 10,0001[1]. There are, however, various barriers to the large scale use of solar energy technologies. Most technologies have in common that the power density of the generator is low; in other words, one needs large areas to generate significant amount of energy. Further, many solar energy technologies have proven technically feasible, but have yet to be proved economically feasible.

Fortunately, these disadvantages are offset by the intrinsic advantages of solar energy. Overall emissions of CO_2 and other gases(associated with construction of solar hardware) are generally small because no fuel is used during the operation. In addition, solar energy, if used correctly, is a renewable source of energy which can be used indefinitely. Finally it can be made available in some form to people in almost all areas of the world.

Conversion of light directly into electric energy involves the photovoltaic effect [2] where photon energy is used to excite an electron from its ground state to an exited state, shown is Figure 1. A functional photovoltaic scheme should implement at least the following three steps,

a) Light harvesting: photons are absorbed and their energy used to excite electrons.

b) Charge separation: the excited electrons are separated spatially from the ground state to avoid recombination.

c) Selective charge transport/ extraction: electrons and holes are transported to the terminals of the device, where the high-energy electrons are selectively extracted at one

In the following, the major PV technologies are outlined with emphasis on issues that impedes a rapid cost reduction.

The PV scheme is implemented elegantly in the classical semiconductor **solar cell [3]**. In

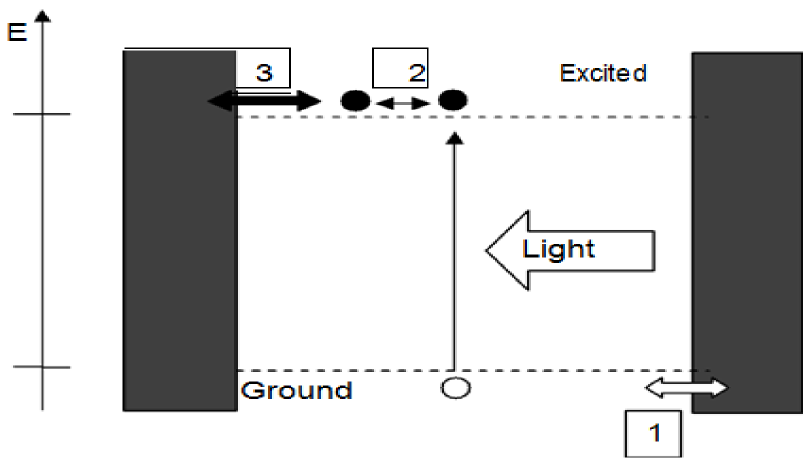

Figure 1 Photovoltaic principle showing the elemental steps:

1) Light harvesting 2) Charge separation and 3) charge transport

these devices all the steps necessary for conversion of light to electric energy are provided by the cleverly manipulated band structure of a single semiconductor crystal. Figure 2 shows the band structure of such a semiconductor p-n junction [4],[5]. Excited electron-hole pair moves to the junction region where the charge carriers are separated. The activated electron is carried through the n-doped region to the negative terminal while the hole is replenished through the p-doped region from the cells positive terminal.

9 1st Generation Photovoltaic Devices

PV units produced today are made from crystalline silicon. In 2000 the equivalent of 103 MW_p was produced from mono crystalline silicon and 104 MW_p from polycrystalline silicon. A small amount was also made from ribbon or sheet silicon. The primary advantage in crystalline silicon is that highly efficient and rugged devices can be made with these technologies. Because silicon is an “indirect band” semiconductor, a relatively thick active layer of silicon is required to absorb the full solar spectrum, and the wafers used to produce these cells are typically several hundred µm thick. They are machined from ingots produced in high-temperature, energy-intensive metallurgical processes, and substantial amounts of materials are last during processing which makes the resulting product cell costlier.

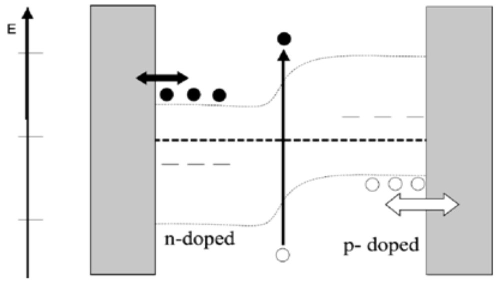

Figure 2 Principle of photovoltaic device based on a semiconductor junction

2nd Generation Photovoltaic Devices

In order to reduce the high material cost intrinsic to 1st generation PV technology, several thin-film technologies are being pursued to enable higher volumes to be produced at a lower cost. Thin-film devices based on amorphous silicon are less efficient than devices based on crystalline silicon, but as this technology is well suited for mass production they can potentially achieve a better price to performance ratio. With ongoing development in performance and production technology, thin-film PV's are becoming increasingly competitive with crystalline silicon, and their production volume is now 30 MW_p per year. Another approach is deposition onto a textured, reflecting substrate. The light reflected from the back contact undergoes multiple internal reflections within the device, allowing weakly absorbed light to pass through the cell many times. Alternatives to amorphous silicon are copper indium diselenide(CIS) and copper indium gallium diselenide(CIGS).

10 3rd Generation Photovoltaic Devices

11 Light trapping Schemes

The scheme has been proposed to achieve light trapping in solar cells as schematically indicated in Figure 3. The type is based on randomizing the direction of light within the cell substrate as shown in figure. Once so randomized, only a small fraction of the light will lie within the escape cone for refraction out of substrate surface from within. The rest is totally internally reflected giving rise to very effective light trapping.

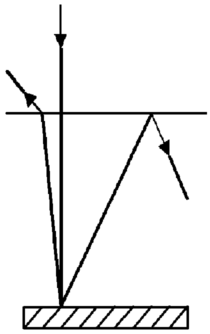

Figure 3 Light trapping approach - scheme based on internal randomization of light direction.

Despite of substantial effort, it has proven to be an obstinate problem to bring up the deposition rates to a level where the high cost of production equipments is balanced by an equally high production volume. It is thus interesting the alternative PV schemes presently are being researched and developed. The scheme outlined below show the promise the low material cost combined with facile, low cost manufacture with an intelligent trap technology.

12 *Problem of Study*

13 *Confrontations in dicing silicon wafers*

The process of dicing silicon wafers off the large silicon ingots forming solar cells has received a noticeable interest in the past few years. Quality characteristics and control parameters of the silicon wafer slicing process were largely investigated by researchers who have also provided a concise description of the process. The processing of silicon wafers involves a good deal of chemistry, physics, vacuum systems, clean environment and complex manufacturing processes. In order to alter the surface conditions and properties of silicon wafers, it is necessary to use both inert and toxic chemicals in highly precise, explicit and unusual conditions which stand the base for improving the **absorption** of solar cells[6].

Starting from big silicon ingot, special slicing machines are used to cut off wafers from these gigantic silicon crystals in the form of thin round disks of 150–300 mm in diameter. In order to build succession of layers of silicon wafer to form solar cells cutting techniques are used by which slicing and grinding is carried out to manufacture defect-free base [7].

14 **Computational Methodology**

In this paper the fuzzy concept is used to pick the best possible silicon wafer slicing technology because the factors of selection of slicing are ‘linguistic’[8]. Some of the factors may be static meaning that they do not depend on a particular manufacturing environment. For instance, the cost factor of a slicing machine is a static characteristic. Contrary to cost, the knife life cycle of a machine can be considered as a dynamic factor in view of the fact that there are plenty of knife types with different quality and excepted life cycles to choose from. The factors consist of 12 criteria as listed below:

I. Cost of the machine: High cost may diminish the competency of a specific machine.

II. Knife life cycle: The knife life cycle has serious influence on its processing capability. As the knife is still used under the state of scrap item, it tends to increase chip defective rate.

III. Machine precision: The accuracy of machine influences the chip quality and the yield after processing.

IV. Parameters setting: A bad setting of the machine parameters would influence the process capability.

V. Establish adjusting standard procedures: Establishing a suite of management procedures and standard processes would make the staff deal with problems, troubleshoot and diagnose systematically.

VI. Engineer’s experience: An engineer has to accept the whole in-service training before working and has to possess the related technical knowledge so as to operate the machine with perfect and sensible setup and settings.

VII. Adjusting time: Proofreading regularly could guarantee the process capability.

VIII. Color management: The color of the wafer is dependent on the thickness of the oxide and surface microstructure. Management of silicon color charts can help the staff to conduct control on the raw material as well as poor yield.

IX. Online education: On-line training could enhance professional knowledge and engineering expertise as well as reducing the errors of the artificial importation and increase productivity.

X. Multi-response: Adequate control should be available for the multiple quality characteristics, which could effectively determine the optimum factor-level combinations and raise the proficiency of the wafer slicing process.
XI. Test methods: A verification method to achieve the most reliable measurement would effectively promote the ability and proficiency of the process.
XII. Measure characteristic: Formulating the quality measurement characteristics and control charts could reduce engineering errors and the error characteristics can be easily identified.

Interpretation of Variable Solutions on to the Model
The dynamic cutting factors are distributed from the marginal values 0 and 1 in intervals of 0.05 where as the static factors are taken constants. As per the cutting technologies there are twelve factors which remain linguistic and those factors are handled for model prediction. These twelve factors of slicing the cells are valued by the fuzzy interpreted min - max marginal values say 0 to 1 and the distribution of the linguistic variable fixation is as in the table 1.

	.05	.1	.15	.2	.25	.3	.35	.4	.45	.5	.55	.6	.65	.7	.75	.8	.85	.9	.95	

Table 1: LINGUISTIC VARIABLE FIXATION FOR CUT FACTORS

Table 2 interpolates the fuzzy interpretation of the first generation solar cells over their dicing techniques whereas the graph 1 interpolates the distribution of solar energy absorption with current density of the first generation solar cells. With reference to the moving average of the accurate predict of absorption of an ideal solar cell the first generation cut techniques provides an average which has a random increase and decrease of absorption in the graduated range of 1 to 12 over the optimal fuzzy range of cut features. Above that over the reference range from 13 to 19 absorption is consistent, but in the low featured fuzzy areas of 0 to 0.2 the absorption moves to minimum meaning that reflection predominates. Thus the current density optimization is found random up to the fuzzy optima of the system and is found bearable at lower fuzzy range.

0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
0.2	0.2	0.2	0.3	0.4	0.5	0.4	0.3	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0

Table 2 : LINGUISTIC VARIABLE FIXATION FOR CUT FACTORS OF I FIRST GENERATION CELLS

Similarly table 3 interpolates the fuzzy interpretation of the second generation solar cells over their dicing techniques and

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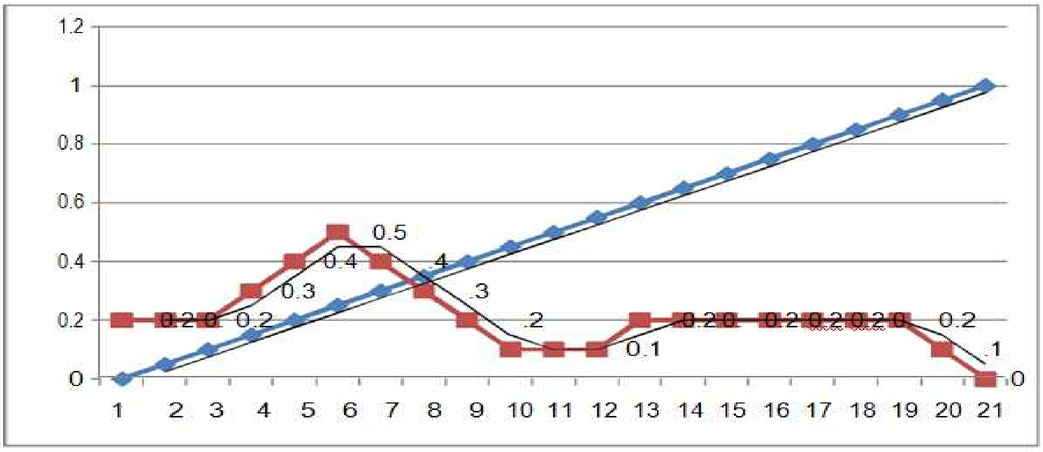
graph 2 interpolates the distribution of solar energy absorption with current density of the second generation solar cells. With reference to the moving average in predict of absorption the second generation cut techniques provide an average as follows. This has a minimum absorption over low fuzzy range of 0 to 0.1 in the reference range of 1 to 12 but a sharpened



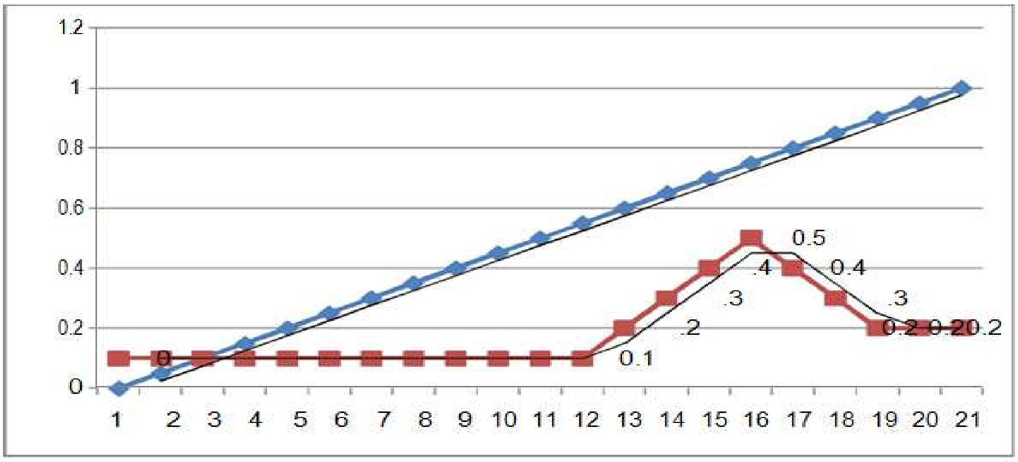
Graph 1 : PLANAR DISTRIBUTION OF ABSORPTION OF ENERGY ON CURRENT DENSITY OF I GENERATION CELLS

absorption from 13 to 16 up to the fuzzy optima and from 17 to 21 of the reference range

the absorption decreases and becomes minimum. Thus the current density of the system over the fuzzy optima is found good implying better absorption than the first generation cells.

0	**0.05**	**0.1**	**0.15**	**0.2**	**0.25**	**0.3**	**0.35**	**0.4**	**0.45**	**0.5**	**0.55**	**0.6**	**0.65**	**0.7**	**0.75**	**0.8**	**0.85**	**0.9**	**0.95**	**1**
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.4	0.3	0.2	0.2	0.2

Table 3 : LINGUISTIC VARIABLE FIXATION FOR CUT FACTORS OF II FIRST GENERATION CELLS



Graph 2 : PLANAR DISTRIBUTION OF ABSORPTION OF ENERGY ON CURRENT DENSITY OF II GENERATION CELLS

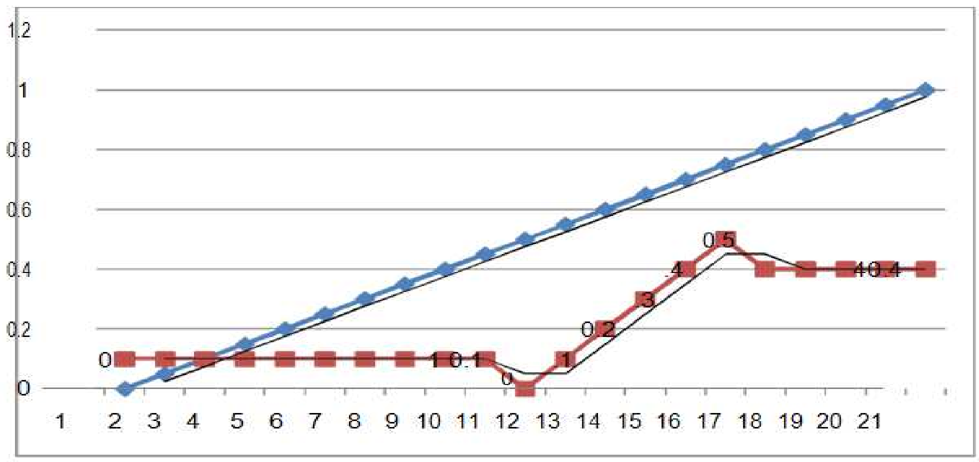
Similarly table 4 interpolates the fuzzy interpretation of the third generation solar cells over their dicing techniques and graph 3 interpolates the distribution of solar energy absorption with current density of the third generation solar cells.

With reference to the moving average in predict of absorption the third generation cut techniques provide a start minimum absorption over the low fuzzy range of 0 to 0.1 in the reference range of 1 to 10 but a highly sharpened absorption from 11 to 16 up to the fuzzy optima of 0.5 and from 17 to 21 of the reference range a bare minimum decrease of absorption is observed in the nearby optimal fuzzy range of 0.4.

By which the current density of the system over the fuzzy optima is observed to be the maximum and still after the optimal range of fuzzy the reflection is observed to be minimum which predicts the maximum current density gain in area of optimal fuzzy and also sustained over the higher optimal range of fuzzy.

0	**0.05**	**0.1**	**0.15**	**0.2**	**0.25**	**0.3**	**0.35**	**0.4**	**0.45**	**0.5**	**0.55**	**0.6**	**0.65**	**0.7**	**0.75**	**0.8**	**0.85**	**0.9**	**0.95**	**1**
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0.1	0.2	0.3	0.4	0.5	0.4	0.4	0.4	0.4	0.4

Table 4 : LINGUISTIC VARIABLE FIXATION FOR CUT FACTORS OF III FIRST GENERATION CELLS



Graph 3: PLANAR DISTRIBUTION OF ABSORPTION OF ENERGY ON CURRENT DENSITY OF III GENERATION CELLS

Conclusion

The fuzzy interpretation on the candidate solutions of the model disseminate the fact that the third generation solar cells are effective in the process of absorption over an unmarked terminal accepted range of optimal values. By which the current density is proportionately uniform in gain over the working range. In view of these features the third generation solar cells can be widened by use as such keeping the cut factors of the cells more linear as before. To improvise the effectiveness the twelve factors of the dicing techniques are systematized for maximum absorption of solar energy.

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