Three Dimensional Solar Cell Technology with Application of Solar Tree

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Abstract

The three dimensional photovoltaic cell is revolutionary silicon solar cell, design to maximize the conversion of sunlight into electricity. It is like container rather than plane conventional solar cell & has 'High Efficiency Design to produce 200% of the Power Output of the Conventional Solar Cells'. Three dimensional solar has a special feature on the surface to capture more light in the morning & evening hours, as well as in the winter months when the sun is not directly overhead. Unlike conventional solar cells where electrical contact wires run on the top of the cell, blocking sunlight, three dimensional solar cell use a network of contact wires run below the light collector. Solar Tree is energy generating & harvesting tree, in order to increase efficiency "SPIRALLING PHYLLATAXY" technique is applied. It is way of mounting the three dimensional solar panel (leaf) on the top such a way that maximum sunlight incident on it. It can be applied in street lightening system, industrial power supply etc. It is much better than traditional photovoltaic solar system in area point of view&also more efficient. It is perfect solution for future energy need&Fibonacci Sequence SolarTree is one of advance solar tree. After using three dimensional solar cell in solar tree, the investment payback period of solar panel systems is40%more than conventional solar panel systems.

1. INTRODUCTION

Silicon has a theoretical maximum light-to-electricity conversion efficiency of 29%, but panels on the market today are only 15 to 18% efficient. Solar3D does not have exact efficiency numbers for its design yet. Solar3D's design will tackle two factors that bring down solar efficiency. First, 30% of the light hitting solar panels is reflected and lost. Second, many of the electrons created when light hits silicon are reabsorbed by the material before they reach the external circuit.

The new design has channels in its top light-collecting layer, which will be made of silicon dioxide or another similar material; these direct light downward, helping to eliminate reflection, Nelson says. The lower layer is an array of three-dimensional structures, each a few micro-meters wide, which trap light by emulating the waveguides used in optical fibers. Optical fibers contain two cylindrical layers with different refractive indices that continuously reflect light back into the core. This 3D structure will allow the light to bounce around until the photons have yielded as many electrons as possible. We'll also put contacts very close to where that happens so that the electrons don't have to travel very far.

Many other light-trapping concepts exist. Another that borrows the technology of optical fibers is a fiber-optic solar cell that Georgia Tech researchers have made by wrapping dye-sensitize solar cells around optical fibers. But solar3D's cells conventional, Simaterial, so they could beproduced on existing manufacturing equipment & be dropped in existing module.

2. DESIGN

Our revolutionary 3-dimensional silicon solar cell is designed to maximize the conversion of

sunlight into electricity. It has developed two breakthrough features in our single wafer silicon solar cell that we believe will deliver benefits that have eluded the solar industry to date.

- **High Efficiency** – Our innovative solar cell technology utilizes a 3-dimensional design to increase the conversion efficiency by trapping sunlight inside photovoltaic micro-structures where photons bounce around until they are converted into electrons.
- **Wide Angle Light Collection** - Our solar cell has a special wide angle feature on the surface to capture more light in the morning and evening hours, as well as in the winter months when the sun is not directly overhead.

We estimate that our patent-pending 3-dimensional cell can produce 200% of the power output of conventional solar cells. This will reduce the investment payback period of solar panel systems by more than 40%. The graph on the right compares our projected efficiency with a conventional solar cell across a range of incident sun angles.

2.1 Wide Angle Light Collection

Conventional solar cells become dramatically less efficient if the sun is not shining within a narrow range of incident angles. Sunlight that hits the cell outside of this range will be reflected off, and the reduced light energy causes the cell's internal efficiency to drop. Because of a unique wide angle design, our solar cell can maintain its high efficiency over a wider range of incident angles. It can capture more light in the morning and evening hours, as well as in the winter months when the sun is not directly overhead. The key to this breakthrough is a special design on the cell surface that collects sunlight over a wide range of angles. The collected light is then forced into 3-dimensional photovoltaic micro-structures beneath the cell surface that trap the light and convert it into electricity. As the sun moves across the sky, throughout the day or year, the Solar3D cell will be able to maintain its high conversion efficiency, as if the sun was directly above it.

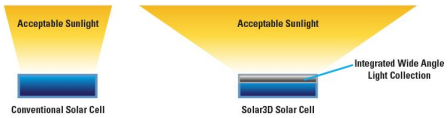

Fig.1: Wide Angle Collection

2.2 High Efficiency

Solar cell efficiency is the measure of how much incident sunlight is converted into electricity. Most solar cells today are made from silicon, an inexpensive and abundant raw material. Due to the physics of silicon, the theoretical maximum efficiency of high-grade crystalline silicon solar cells is approximately 29%. In commercial practice, the efficiency ranges from 15% to 19%.(1) Our 3D solar cell is calculated to have an internal efficiency of 25.47%, more than any existing silicon solar cell, and is designed to take advantage of low cost manufacturing processes.

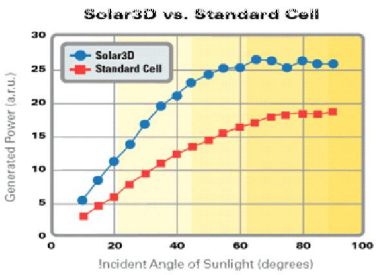

Fig.2: Solar 3D vs. Standard Cell

3. THE PROBLEM-LIGHT REFLECTION AND ELECTRON LOSS-

Conventional solar cells are 2-dimensional, utilizing a single pass sunlight conversion mechanism. There are two primary ways that these devices lose light and electrons or electron-hole pairs, which result in a conversion efficiency much less than the theoretical maximum.

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3.1 Surface Reflection

Due to fundamental physics, approximately 30% of incident sunlight is reflected off the surface of silicon cells.

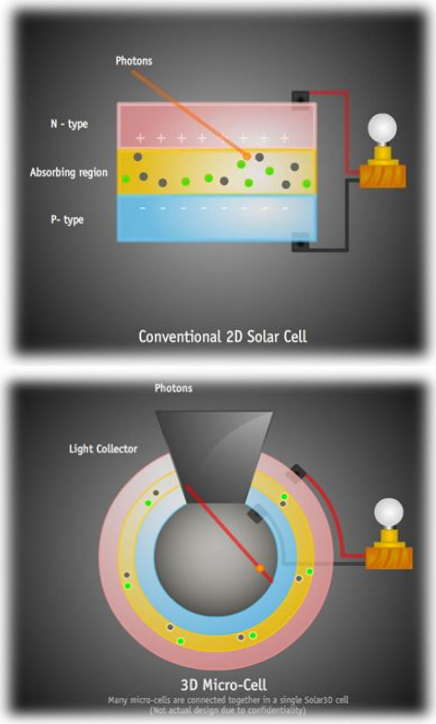

Fig.3: Surface Reflection of 2D and 3D Cell

- **Electron Re-absorption** – When a photon strikes the solar cell, an electron is "knocked loose" creating an electron-hole pair that moves through the cell material, creating electrical current. However, in conventional 2-dimensional solar cell designs, these electron-hole pairs must travel a long distance before reaching a metal contact wire. As a result, they are reabsorbed by the material and do not contribute to the production of electrical current.

3.2 Morning, Evening and Winter Light Loss

Conventional solar cells reach their quoted efficiencies of 15%-19% only when the incident sunlight is within its narrow acceptable angle. During morning and evening hours, and winter days, the sun is shining from outside of this angle. As a result of the reduced flux in solar energy during these times, the operating efficiency of conventional solar cell is often below its quoted number.

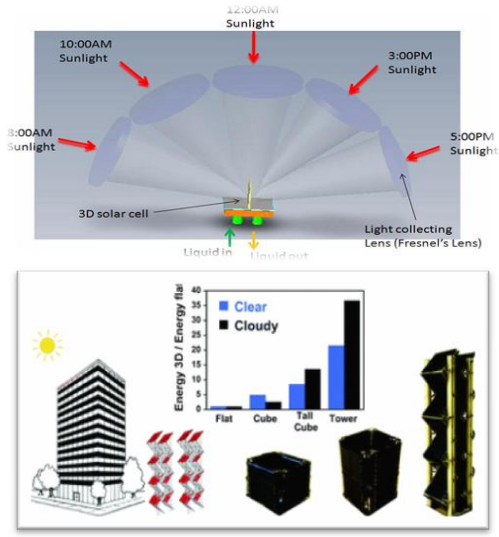

Fig.4: Light loss comparison of conventional cell vs 3D cell;

4. THE SOLUTION – 3D LIGHT TRAPPING AND ELECTRON EXTRACTION

Solar3D's 3–dimensional solar cell is designed from the ground up to optimally reduce all primary losses to achieve the highest conversion efficiency. By leveraging the high volume scalability of conventional solar and semiconductor processes, we believe our 3D solar cell can deliver an unprecedented low total cost of ownership for any given solar installation. Unlike conventional solar cells where sunlight passes through one time, our 3D solar cell design traps sunlight inside photovoltaic structures where photons bounce around until they are all converted into electricity. The key features and benefits of our 3D solar cell design are:

- **Wide Angle Light Collection** – Instead of allowing sunlight to bounce off the surface, our unique wide angle light collection feature is engineered to capture light from a wider range

of angles Ð including morning, evening and winter angles – and guides all incident sunlight into a subsurface micro–photovoltaic structure.

- **3D Photovoltaic Structure** – Conventional solar cells have only one photon absorbing surface. We use a multi-facetted 3D photovoltaic structure where photons can bounce off many surfaces until all photons that can be absorbed by the material are absorbed.

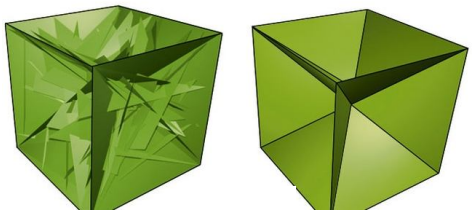

Fig.5: 3D Photovoltaic Structure

- **Thin Absorbing Regions** - Our 3D photovoltaic structure will be fabricated with very thin absorbing regions and designed to enhance charge carrier separation. Therefore, electron-hole pairs will travel short distances before reaching a contact wire where they will be quickly extracted to produce current. This approach also leads to an overall height and silicon material reduction when compared to conventional crystalline silicon cells.
- **Below Surface Contacts** – Unlike conventional solar cells where electrical contact wires run on the top of the cell, blocking sunlight, our design uses a network of contact wires that run below the light collectors. This approach allows our 3D solar cells to trap and utilize nearly 100% of the incident light.

4.1 An Extraordinary New Solar Cell

Solar panels using Solar3D cells can be installed on smaller surface areas, due to our 3D cell's high efficiency and high power output features. Solar panels using Solar3D cells will not need tracking systems that follow the sun to maintain high efficiency because of its wide angle light collection feature. Solar panels using Solar3D cells can be installed flat on surfaces that do not face the sun directly, eliminating the need for unsightly mounting structures.

From solar farms, to rooftops, to mobile devices, to military applications, to consumer products, we believe our Solar3D cell will be the obvious choice for next generation solar panels. We believe we can dramatically lower the Total Cost of Ownership of solar panel systems. Our low cost, high efficiency solar cell also eliminates the need for supporting components such as tracking systems and mounting structures. Our innovative solar technology will make solar cells substantially more useful in substantially more applications.

Beyond Silicon Our initial commercialization objective is to create a low cost, high efficiency silicon solar cell based on our 3D technology. By keeping our focus on silicon, we can leverage the tremendous silicon infrastructure and manufacturing processes of the growing solar industry, as well as the mature and highly optimized semiconductor industry. However, since our focus is on re-engineering the solar cell, our 3D technology is materials agnostic and can be used with other materials for use in concentrated solar and high performance applications.

5. SOLAR TREE

A solar tree is a decorative means of converting solar energy into electricity. It uses multiple number of solar panels which forms the shape of a tree. The panels are arranged in a tree fashion in tall tower/pole.

TREE stands for

T= TREE GENERATING

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R= RENEWABLE

E= ENERGY and

E= ELECTRICITY

This is like a tree in structure and the panels are like leaves of the tree which produces energy. Industrialized countries the energy consumption has been increasing at a very fast rate. Because of increasing energy and growing population one option to fulfil the increasing demand of energy is renewable energy source. Keeping this option in mind we should also take care that energy should not cause pollution and other natural hazards. Therefore no conventional energy sources such as ocean tides, geothermal, sun and wind are good option. With this alternative energy sources we can fulfil the energy demand in coming future. In all these alternatives solar energy has more advantages for the mankind i.e. Solar Energy is free, inexhaustible and non-polluting. Solar energy is most advantageous for countries having very less space to produce energy efficiently and having very large population like India. In all these solar tree could be the best option. The efficiency of the plant can be improved by using the technique known as "SPIRALLIN GPHYLLATAXY". This technique can also be used for system of street lighting, industrial power supply etc. In area point of view, solar tree is more efficient and much better than the traditional solar PV system. Therefore it should be implemented. Solar energy is available in very large amount and also easily available. The solar radiation can be directly converted into solar photovoltaic, solar thermal and solar architecture. The installation of large solar collectors requires a very big space which is the main problem associated with tapping solar energy .This problem can be avoided by installing a Solar Tree requiring less space instead of ano of solar panels. To satisfy pressing environmental and social demands for urban lighting solar tree opens new prospects.

5.1 Spiralling Phyllataxy

Spiralling Phyllataxy technique is used in designing of Solar Tree. For tracking maximum power from sun this Technique helps the lower panels from the shadow of upper ones. The efficiency of the plant can also be improved by this technology.

5.2 Reason to be called as Solar Tree

As we know trees are present in nature and they can produce their own food material by the process called PHOTOSYNTHESIS. It is the process by which the green plant collects energy from sun and the water present in soil at the day time and can produces their own food material. By this process they are indirectly providing food to the human society because we are depending on the green plants for our food directly or indirectly.

Here we are considering the example for understanding about the solar tree. This is a tree in which the stems connected acts as the branches of the tree and the solar panels are like the leaves. Green leaves are producing food materials for human beings likewise this leaves are producing energy for the society. So it is very appropriate to called it as a tree.

5.3 Need of 3D Solar Cell Tree

- **Less Land Requirement**:- In comparison traditional PV system, Solar Tree requires less land. Therefore a plant is generating maximum Energy by using minimum land.
- **Efficient Energy Generation:**-Solar Tree can generate energy very efficiently.

6. CONCLUSION

To fulfil the increasing energy demand of the people, saving of land. The 3D solar cell tree concept is very successful one and should be implemented in India to provide electricitywithout the problem of power cut. It is 200% more efficient than conventional 2D solar cell tree. For country

like India, where population density is high, so energy demand is also high. 3D solar cells become alternative one as area & ecology point of view.Also it is efficiency goes on increasing after development of various patter of 3D solar cells. It is botanic 3D solar cell trees, so produce a non-conventional electrical energyhaving many advantages as compared to the other sources. It is therefore the responsibility on the shoulders of the youngsters of the earth to think smartly and take the right decision. Everyone should starts as an individual to co-operate with the government to make life favourable for mankind.

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