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Photovoltaic Thermoelectric Solar Generation Technique

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***Abstract* — At this age of non-conventional energy consumption, we are much developed about sources of solar energy. But still we are lagging in this field related to efficiency, cost and limitations of area. The maximum inventions about solar photovoltaic, Higher efficient (>30%) PV cells have been created from gallium arsenide (GaAs) and indium phosphide (InPh), but these solar cells are used for special applications because of its cost. The range of efficiencies in 18% - 24% is used for commercial purpose which is made by silicon both multi-crystalline and single-crystal materials. Major advances in efficiency and design such as transparent solar cell have been done. This paper gives introduction of the new type of PV panels with high efficiency and having capacity to generate maximum power at less space based on combination of photovoltaic and thermoelectric generation.**

***Key Words* — PV cells, photovoltaic's, silicon, thermoelectric generator, thermocouple, venatablack, vanadium dioxide.**

I. Introduction

The main topic of invention in solar power in the world is to improve the efficiency of photovoltaic (PV) solar cell and all this work is to reduce the cost of PV modules up to that at which solar power generation will be possible by the middle class people. There is a one option to increase the conversion efficiency of PV cells and devices. Basically, there are some factors on which the efficiency of solar cells is depends: (1) the semiconductor materials which having energy band gaps range between 05-12eV and (2) innovative fabrication technique of solar cells, which enables more effective charge collection and maximum utilization of the solar radiation through single and multifunction approaches. There is point of which type of material is used in cell for high efficiency but it is very important that a given material how it impacts the overall cost structure. However, in the current position it is possible to classify a select group of materials into different efficiency ranges: (1) ultrahigh-efficiency devices (η>30%)GaAs and GaInP2; (2) high-efficiency cells single-crystal silicon; (3) medium-efficiency cells (η=12%-20%) polycrystalline silicon, amorphous and microcrystalline silicon, copper gallium indium solenoid (CIGS), and cadmium telluride (CdTe); and (4) low-efficiency cells (η<12%) dye-sensitized nanostructure TiO2 solar cells. And now here this is new type of module is created with the combination of photovoltaic cell and thermoelectric generator which is fabricated by the doping of vantablack or vanadium dioxide which is a light absorbing material. In this paper the whole design, working and advantages with cost determination is described.

II. Types Of Solar Energy Converters

1) The photovoltaic convertors are divided into two type's namely as solar thermal and photochemical converters. Solar thermal energy converters results into exchange of heat from hot body (sun) to cool body (solar converter).
2) And on other hand the photochemical energy means the radiant energy absorbed by device can either increase the kinetic energy of atoms and electrons in the absorbing material results into increase in the potential energy of electrons.

a) Currently using panels:

SR	Type of Solar module	Efficiency
1.	Amorphous thin film silicon	7%
2.	Polycrystalline silicon	13%
3.	Monocrystaline silicon	15%
4.	Hybrid silicon	18%

Table 1. Conventional solar modules and its efficiency.

III. Limitations Of Conventional Cell

Main limitations of conventional solar cells are as following:

- This type of solar cell (table 1). Are totally dependent on whether conditions means on intensity of light or sunshine. In the rainy season or in winter season there is much less solar radiation so that we get lack of power supply. Mostly all the industries are not interested to invest in solar generation due to this.
- Second problem is that there is a limitation of land, so that industrial area is not capable to provide that amount of land and also commercial purpose mostly in urban area there is much demand of land, so in that case there must be higher efficiency solar panels which provide sufficient power at less space.
- The absorption of light is not done by these cells sufficiently.

IV. THE PHYSICAL STRUCTURE OF SILICON CELL

Silicon Solar cell technology consists of two features:

- The physical structure of solar cell.
- The production technology.

The silicon solar cell is the basic structure from which we can design other type of structures which gives us more efficiency so that it is necessary to understand the basic structure , in thus section the basics of silicon is described.
For the working of solar cell at least three structure elements are require.

- Particular type of absorber which absorbs incoming solar rays and radiation and transforms their energy to excited state of charge carrier. Typically this process creates an electron in the conduction band.
- The membrane of p type and n type junction which prevents the reverse process to happened in which excited carriers recombines to its low excitation.
- Connections of metal or conductor which interconnects to other solar cell.

The p-type wafers form the base of the cell and is thick (300-500µm) in order to absorb as much light as possible and lightly doped (~100^{16} cm-3) to improve diffusion length. The n-type emitter is created by dopent diffusion and is heavily doped (~10^{19}cm $^{-3}$) t reduce sheets series resistance. This layer should be thin to allow as much light as possible to pass through to the base, but thick enough to keep series resistance reasonably low. Carrier collection from the emitter is negligible because of higher recombination in this heavily doped layer. The front surface is anti-reflection coated and both front and back surface are contacted before in capsulation in a glass covering.

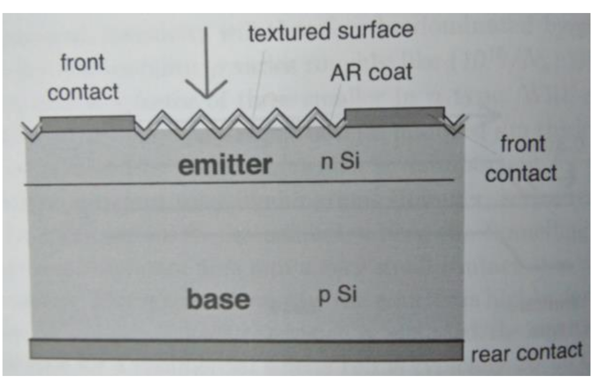

Fig. 1 Structure of silicon cell

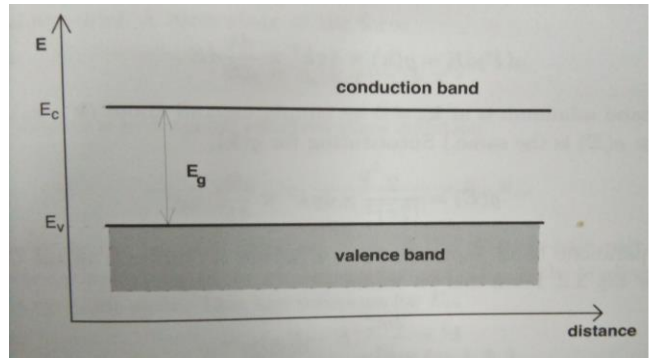

Fig. 2 Moment of electron between two energy gaps

V. FACTOR AFFECTING THE EFFICIENCY OF THE PANEL

- Energy gap:- there is condition of energy or band gap which should be satisfy by the molecular material of solar cell. . With band gap in the range 0.5-3 eV semiconductors can absorb visible photons to excite the electrons across the band gap, where they may be collected.
- Light absorption:- Increasing the thickness of absorbing layer increase its optical depth. The requirement of high optical depth and perfect charge collection, make very high demand material quality.
- Charge separation:- For a current to be delivered, the material should be contacted in such a way that the Promoted electrons experience a spatial asymmetry which drives then away from the point of excitation, these can be electric field, or a gradient electron density.
- Lossless transport:- To carry the charge to the other solar cell the material of a conductor should be super conductor.
- Optimum load resistance:- The load resistance should be match with the maximum point of the array rather than the cell

(1)

VI. MAIN TWO PARAMETERS OF EFFICIENCY OF CELL

Light absorption:-

Texturing of front surface of solar cell:- This reduces the reflection of light rays and increases the optical depth of the cell. Texturing can be achieved by mixed with an anisotropic chemical etc. which acts preferentially along the (111) crystal planes and leaves a pattern of pyramids on the surface. Regular pyramid can be produced on a monocrystalline surface by photolithographic definition. Light trapping is improved by using inverted pyramids, which improve the total internal reflection of light reflected from the back surface.

Temperature:-

High concentration raises the temperature of the cell. At the higher temperature the intrinsic carrier population Increases, an effect which is enhanced by shrinkage of the band gap Eg with rising temperature. Increasing n_i increases the dark current. The reduced band gap increases the photocurrent, but only slightly compared to the effect on J_{dark}, so increasing dark current dominate. This opposes the effect of increasing efficiency under concentration with the result that optimum performance is achieved at some intermediate concentration level. GaAs has a slightly better temperature coefficient of efficiency than silicon and find its optimum at a higher concentration level.

$$n_i^2 \sim e^{-Eg/kBT}$$

Where,

n_i = Intrinsic carrier density

Eg = Band gap

k_B = Boltzmann's constant

VII. Design Of PVTG (Photovoltaic Thermoelectric Generation)

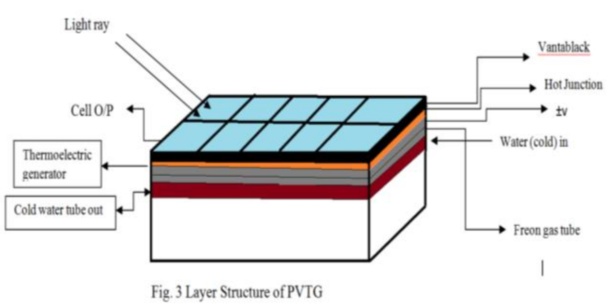

Fig. 3 Layer structure of PVTG

As shown in above Fig.3 the layer structure of PVTG is fabricated. Each layer is described as following:

Photovoltaic layer:- The first layer is fabricated which is any one type of solar cell available in this age, But there is one change in this cell that is the Vandium Dioxide material is in the silicon material as a impurity. This addition of Vanadium Dioxide material increases the absorption of light rays. The whole Layer is act as PV arrays which absorbs maximum light and convert it into electricity.

Vantablack Layer:-Second layer is of Vantablack layer which act as a absorber of light as well as it dissipate the absorbed light in form of heat. This layer act as a hot junction of the thermoelectric generator. Light from the first layer is transferred into second layer and feed to the vantablack. Vantablack dissipate it into the heat.

Thermoelectric Generator Layer:- In this layer thermoelectric modules are placed which converts the heat into electricity. This layer is sandwiched between Vantablack layer and coolant layer.

Coolant Layer:- This layer is very similar to Freon gas layer used in refrigerator . Whenever heating applications are at off conditions then the coolant layer get activates which carry out the heat generated from vantablack layer to the fins. It is off when the heating applications are activates. It is also act as secondary cold junction of thermoelectric generator.

Water Layer:- In this layer cold Water is present continuously passing. There are to terminals from one terminal cold water is entered into layer then the heat generated from the Vantablack layer is transferred to this layer. And water gets heat up. Mainly this layer is known as primary cold junction of thermoelectric generator.

VIII. Working Of PVTG Array:-

- When light incident on the surface of PVTG array Maximum light will be absorb by the cells because of the impurity addition and power generation takes place effectively in less intensive light also.
- Due to the second layer and Vantablack impurities this light energy absorbed by Vantablack will dissipate into heat.
- In the third layer thermoelectric generators are available. Heat dissipated from second layer is works on the hot junction of the thermoelectric generator.
- We provide water tubes in fourth layer through which cold water is passing continuously. This cold water acts as a cold junction of thermoelectric generator. **Seebeck effect** takes place and heat is converted into electricity. This power is added to the main output of this system. This power is the advantage point of this system.
- Now when Cold water is in operation of thermoelectric generator this cold water will heat up due to heat exchange process. This hot water can be used in the heating applications of the household purpose.
- Whenever the application of heating in house is not required then simply turn off the tap of cold water tubes and turn on the secondary coolant layer of the system. This will prevent an increase in the temperature of the system.
- Due to Vantablack temperature is increases of cell up to predetermine levels which will helpful for

intrinsic carrier population which results into the increase in efficiency of the cell.

IX. Advantages Of PVTG Solar Array

- Mainly efficiency is improved Due to maximum absorption of light in this panel.
- Due to thermoelectric generator better utilization of generated heat which is converted into electricity.
- Heating applications of household purpose is achieved very well.
- Maximum utilization of radiation of solar.
- At less space there is as much as electricity is generated. Space requirement is much less as compared to other panels.

Conclusion

This paper is on the new structure of PV array which combines thermodynamics technology also. By adding the absorber impurity we get efficiency more than the conventional solar panels. Also there is application of heat. We get such idea to minimize the space requirement for maximum generation of solar power. Due to this advantage of this type of panels, Industrial world will attracted towards the solar generation. And of course these will results into the reduction in overall pollution of atmosphere.

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