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PHOTOVOLTAICSWITH NANOTECHNOLOGY

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Abstract- Increasing pressure on fossil fuels for energy and their non-reliability in the near future has caused to look towards the renewable sources of energy to meet the present as well as future demands of energy. Many researches are being carried out to find a solution to get clean and reliable energy source. One such renewable source of energy is the solar energy photovoltaic that convert the sun's energy to electrical and heat energy.

There are limitations to solar energy that abandon their mass utilization and provide significant challenges to the power sector. The major problem with solar photovoltaic is that they are not efficient, accounting about 12-15% efficiency and the output energy received is quite less that directly affects the cost of per watt power which is much higher than nonrenewable energy resources.

Output energy of solar cells directly depends upon the surface area available for absorption of photons and their conversion to useful energy. What if the output energy obtained could be made almost ideal? This can be achieved by applying nanotechnology. Nanoscale materials have far larger surface areas than the materials with the same masses. If the surface material of solar cells (mainly silicon) is replaced by such nanostructures with required electronic band gap to absorb more photons of the solar spectrum, the output energy of photovoltaic can be highly increased. If such nanofilms be properly aligned to the cell, we can have an ideal photon collector. It will directly reduce the cost of energy production as more energy output is achieved.

The basic step of achieving such a model of photo cell is the choice of material that can be nanostructured and put to use as the surface photon absorber to increase the photon absorption(P3HT(poly (3-hexylthiophene)), and M3H-PPV (poly[2-methoxy, 5-(2′-ethyl-hexyloxy)-p-phenylenevinylene)).

Index terms- choice of material**,** efficiency of solar cells, larger surface area, nanotechnology, photovoltaic, conventional cells which are rigid and expensive, colloidal semiconductor nanostructures.

1. INTRODUCTION

Utilization of non-renewable energy sources has led the world to an unbalanced state of environment and economy. There is no proper check on the pollution caused by automobiles and engines which is resulting in the worldwide problem of global warming and other health hazards. This has led to the search for alternate resources of energy for mass utilization. The major problem being faced to accomplish this requirement is that the renewable energy resources are not that reliable with respect to their efficiency and cost as compared to conventional energy sources like coal and petroleum. Researches are being carried to find a solution for obtaining a renewable source that is economic as well as efficient. Solar energy in this regard is considered to be of the highest potential. But again the problem with solar energy is that it is not an efficient source of energy. Solar energy is stored in various ways. Solar photovoltaics or solar cells are the devices that convert solar energy to electricity. The solar energy generated is direct current which is then sent to inverters to convert into alternating current for household circuits and businesses. The efficiency of these solar cells is nearly 13-17% that is quite low as compared to the fossil fuels which abandons their mass utilization. Researches are carried out to increase the efficiency of solar cells so that they can be effectively replace conventional sources with better results. To reach this aim, it is required that the solar cells must provide a good efficiency and imply reasonable cost.

The statistics of solar energy capacity show huge growth in the past years.

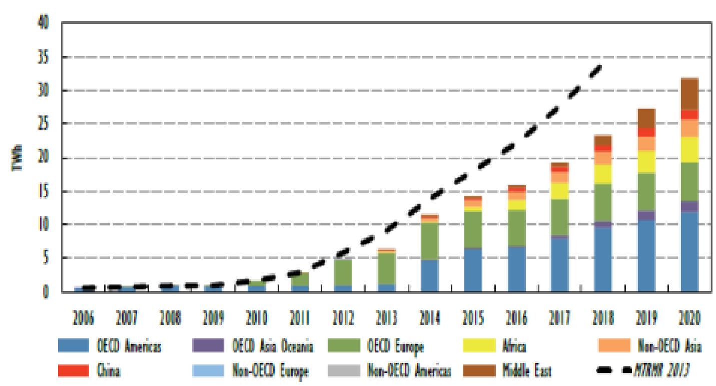

Fig.

The parameters on which the efficiency of solar cells mainly depend are the energy band gap of the material used as absorber, area of the solar cell available for absorption and the intensity of light from the sun. For a particular material used as an absorber of solar energy, more the area of the absorber exposed to sunlight will account for more photon absorption and higher electron hole pairs formation with higher current generation. For increasing the surface area exposed to sunlight of the same material and same available ground space, nanotechnology is one of the technique that can be implied to the solar cells absorber semiconductor materials. Nanotechnology is the science that deals with the formation of nanostructured materials to increase the reactivity and surface area of the materials. If nanostructured films are used as solar energy collectors, there will be more surface absorption and different energy band gap collection can be achieved. If these electronic charge produced be transferred to the inverter by nanowires, loss of energy due to heat can be tremendously reduced.

2. NANOTECHNOLOGY

Nanotechnology is basically the working on nano-size materials of size 1-100 nanometers.

2.1 Concept of increased surface area

If we take a cube of area $1cm^2$ than it has 6 surfaces of 1cm each exposed outwardly. If we cut this cube from the middle, we get 2 more surfaces exposed. The total surface area of the new cuboids formed will be obviously greater than the cube. Similarly if we cut this cube into 10^9 (nano) particles, then we get a lot more surface area exposed outwardly.

2.2 Advantage of increased surface area on the efficiency of solar cell

The efficiency of solar cell is directly related to the no of photons absorbed by the cell of proper band gap that give enough energy to the loose end electrons of the atoms to produce an electron hole pair and free a loose end electron from the atoms of the semiconductor and contribute these electrons to the electric current. This is basically achieved by a p-n junction. The electrons after attaining energy from the photons become free and enters the circuit in the direction from the positive potential to the negative potential, thus allowing current to flow from the positive potential to the negative potential(direction of current is reverse of the direction of the movement of electrons).

Since the surface area of the semiconductor used for absorbing photons can be tremoundously increased by the application of nanotechnology, there will be more area available for the semiconductor to absorb photons of the required energy band gap and hence more electron hole pairs will be formed. This will directly affect the current generated by the solar cell.

Application of nanotechnology on the semiconductor will also produce more loose electrons on the atomic surface level as the semiconductor is not in a pure solid state, rather it comes in a powdery state and the intermolecular and interatomic forces become less. As a result, less energy photons will also be able to make the escape of those loosely held electrons.

If these electrons that are obtained are made to flow through the circuit to the storage with the help of nano wires, the heat loss is reduced.

$$H = I^2 RT \quad ,$$

Where H is the heat, I is the current, R the resistance of the wire. From the equation it is clear that the heat energy is directly proportional to the square of the current. Since a bundle of nanowires will be used for the transport of charge, the amount of current flowing through a single wire will reduce, and the resistance of the system will also reduce.

3. Choice of material

A variety of colloidal semiconductor nano-crystals can be used for the fabrication process of nanostructured solar cells. Highly doped zinc oxide films have already been proved to compete the conventional ITO (INDIUM-TIN-OXIDE). Hybrid nano-films can also be made by the mixing of organic material with high electron transport material.

Orientation of the nanostructured material should also be kept in mind. Cylindrical nanostructures for the application of solar cells have given better results.

4. Efficiency of solar cells

The efficiency of solar cells is subjected to the following parameters: thermodynamic efficiency, quantum efficiency, integrated quantum efficiency, v_{oc} ratio and fill factor.

Fill factor is the ratio of the actual maximum obtainable power to the product of the open circuit voltage and short circuit current. Since by the increased surface area of absorption, the maximum obtainable power increases, fill factor increases.

$$FF = P_M/(V_{OC}*I_{SC}) = (\eta * A_C * G)/(V_{OC} * I_{SC}) \quad , \eta =$$
efficiency of solar cell,

Since above equation clearly states that efficiency is directly proportional to the fill factor, increasing the fill factor increases the efficiency of the solar cell.

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5. Result and Discussion

Nano structures can be used to enhance the performance of existing photo voltaic device by increasing the fraction of light that is available for conversion into electrical output. Nano-structuring the light- absorber layer of semiconductor result in low reflection and increased photon absorption. This in turn can lead to higher cell efficiency without the need for additional anti reflection coatings. However large surface areas in nano structures increase charge carrier recombination which is detrimental to efficiency. Solar cells based on arrays of semiconductor nano wires can also demonstrate efficient light trapping, and could reduce material cost because less material is used than in planar cells.

6. Conclusion

Despite the potential of nanostructured solar cells to push efficiencies up and cost down, at present the efficiency of these cells is rather low. Moreover, several challenges must be addressed before these technologies can make it to the market and compete with conventional cells which are rigid and expensive but are stable.

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