ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization Volume 3, Special Issue 2, April 2014

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

Production of Solar Energy Using Nanosemiconductors

[1]Kiruthika S , [2]Dinesh Kumar M, [3]Surendar.A

[1, 2] II year , KSR College of Engineering, Tiruchengode, Tamilnadu, India

[3] Assistant Professor, KSR College of Engineering, Tiruchengode, Tamilnadu, India

ABSTRACT: Solar energy is a well known form of non-conventional and renewable energy. Though sun's light energy is available in plenty, but still it is not widely used because of its drawbacks namely: a) High cost of production involved in the production of solar cells, b) Most of the photons (particles of light) are left unabsorbed due to mismatch between the energy of photons and energy of semiconductor material c) loss of photogenerated electrons due to recombination with holes of p doped material.

By Nanotechnological approaches we can replace conventional solar cells by multijunction solar cells made of different semiconducting materials and using different methods for synthesis of cells & by the use of nanoscale heterojunctions we can reduce the thickness of solar cells and thus increase the surface area to volume ratio. As the amount of raw material is lowered, thus cost of production is reduced. Efficiency also increases as the cell absorbs photons of different energies. Thus these nanosolar cells can be easily painted on the roofs of buildings, buses, cars etc. to trap the solar energy.

I.INTRODUCTION

- Nanotechnology is the design, characterization, production and application of structures, devices and systems by controlling shape and size at the nanoscale.
  Also defined as:
- The understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications.

Potential benefits

- With Nanotechnology, a large set of materials with distinct properties (optical, electrical, or magnetic) can be fabricated.
- Nanoparticles take advantage of their dramatically increased surface area to volume ratio.
- Nanoparticles have an influence on the optical properties,mechanical properties.
- Nanotechnologically enhanced materials will enable a weight reduction and increase in stability and an improved functionality.

Applications of Nanotechnology

Medicine

- Drug delivery, diagnostics, tissue engineering, medical imaging.

IJIRSET

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization Volume 3, Special Issue 2, April 2014

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

- Information and Communication
- Semiconductor and optoelectronic devices.

Consumer goods

- Sports & textiles
- Cosmetics & Optics
- Household & food

Energy

- Reduction of energy consumption.
- Increasing the efficiency of energy production.

Space technology & transportation

- To monitor the amount of radiation that astronauts encounter.
- Fiber-optic probes, such as the one seen here, to collect light emitted by nanoparticles that have been introduced into the bloodstream. Investigators glean information from the collected light to monitor cells for radiation exposure.

What is Solar energy??

- It is the energy obtained from Sun.
- Sun is the ultimate source of energy, directly or indirectly for all other forms of energy.
- Solar energy is the solar radiation that reaches the earth.
- The solar energy received by the near earth space is approx. 1.4 kJ/sec/m^2.
- Solar cells form an important role in producing solar energy.

The process

- After a photon makes it's way through the encapsulate it encounters the antireflective layer. The antireflective layer channels the photon into the lower layers of the solar cell.

- Once the photon passes the AR coating, it will either hit the silicon surface or the contact grid metallization. The metallization, being opaque, lowers the number of photons reaching the Si surface.

- The photon's energy transfers to the valance electron of an atom in the n-type Si layer. That energy allows the valance electron to escape its orbit leaving behind a hole.

- So, a region known as the depletion region left around the junction causes a small electrical imbalance inside the solar cell. This electrical imbalance amounts to about 0.6 to 0.7 volts.

- When photons hit the solar cell, freed electrons (-) attempt to unite with holes on the p-type layer. The PN-junction, a one-way road, only allows the electrons to move in one direction.

IJIRSET

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization *Volume 3, Special Issue 2, April 2014*

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

Solar cells

- They are devices or banks of devices that use the photovoltaic effect of semiconductors to generate electricity directly from sunlight.
- When solar radiations fall on them, a potential difference is produced which causes flow of electrons and produces electricity.
- Most commercial solar cells today are made from silicon. Use of silicon leads toà high cost of production.
- Fabrication of the simplest semiconductor cell take place under exactly controlled conditions, such as high vacuum and temperatures between 400 and 1,400 degrees Celsius.

Photovoltaic cell

- The photovoltaic cell is the basic building block of a PV system. However, one cell only produces 1 or 2 watts.

so, to increase the power output…

- Cells -------> packed into modules -------> connected in series to form arrays
- The performance of a photovoltaic array is dependent upon sunlight. Climate conditions (e.g., clouds, fog) have a significant effect on the amount of solar energy received by PV array. Most current technology photovoltaic modules are about 10 percent efficient in converting sunlight.

Efficiency

- A junction between n-type and p-type doped semiconductors creates a voltage bias.
- Photons with lower energy than the band gap escape unabsorbed, photons with higher energy are absorbed.
- But most of the energy -------> wasted as heat.
- Silicon solar cell efficiencies vary from 6% for amorphous silicon-based solar cells to 30% or higher with multiple-junction research lab cells.
- Solar cell energy conversion efficiencies for commercially available *mc-Si* solar cells are around 14-16%.
- For example a 30% efficient multijunction cell and produced in low volume might well cost *one hundred times* as much as an 8% efficient amorphous silicon cell in mass production, while only delivering a little under *four times* the electrical power.

Major drawbacks

High cost of production

- Solar cells are manufactured using pure silicon. Extraction and purification of silicon involves high cost.

Loss of photons

- Much of the photons are left unabsorbed à energy of photons lower than band gap of semiconductor.

Conversion efficiency

- Most of the Photogenerated electrons (that are responsible for the electricity generated) combine with holes and are lost.

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization Volume 3, Special Issue 2, April 2014

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

“OVERCOMING THE DRAWBACKS USING NANOTECHNOLOGY PRINCIPLES”

- Nanotechnology can be used to produce a photovoltaic material that can be spread like plastic wrap or paint.
- To improve the efficiency, we use a new ingredient called Nanorods-------> bar-shaped semiconducting inorganic crystals measuring just 7 nanometers by 60 nanometers.
- The result is a cheap and flexible material that could provide the same kind of efficiency achieved with silicon solar cells.
- The Nanorod solar cells could be rolled out, ink-jet printed, or even painted onto surfaces, so “a billboard on a bus could be a solar collector”.
- There exists a common problem with conversion efficiency where the photogenerated electrons (or the electrons ejected during the photoelectric effect) and holes can recombine and are hence lost for power conversion.
- If the solar cell can be made using nanoscale heterojunctions, then the problem of recombination through traps can be greatly reduced.
- With nanoscale diffusion lengths, the materials constraints can be relaxed.

Nanotechnological approach

- In this approach we shall use a nanostructured substrate that is coated with semiconducting layers.
- First is the synthesis of nano scale semiconducting materials.
- Second is the deposition of this semiconducting layer over the substrate.
- Briefly we can say that here we use a nanostructured multi junction solar cell.

Synthesis of nanoscale semiconductors

- These rod shaped nanometer sized crystals can be made out of quantum heterostructures eg:- quantum dots or carbon nanotubes.
- By varying the size of the quantum dots, the cells can be tuned to absorb different wavelengths.
- Quantum dots: They are dimensionally confined structures that make use of some of the same light absorbing materials from thin-film configurations, but are suspended in a supporting matrix of conductive polymer.

Methods of Synthesis of nanoscale semiconductors

These nanostructured materials can be synthesized by a number of techniques:

- Inert gas condensation
- Plasma processing
- Mechanical alloying

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization *Volume 3, Special Issue 2, April 2014*

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

- Rapid solidification
- Sol-gel
- Micro-emulsion
- Spark erosion
- Severe plastic deformation.

Sol – gel method of synthesis

- In this method the nano composite of the material is dispersed in a suitable matrix such as Si matrix etc. using the sol gel method in the presence of suitable chemicals.
- The chemical to water ratio is maintained constant and solution is heated at specified temperature and then allowed to form gel at the same temperature.
- This gel is heated at different temperatures till the formation of the nano crystals.
- Further it is heated for the growth of the crystals.Depending upon the matrix chosen, the shape of the nano crystals can be changed.

Pulsed laser deposition

- It is a thin film deposition technique where a high power pulsed laser beam is focused inside a vacuum chamber to strike a target of the desired composition.
- Laser light used here is of the wavelength of 10nm.
- Due to the strong electromagnetic field created by the laser, energy is sufficient to remove electrons from target material.
- These electrons oscillate along with electromagnetic field and transfer a part of energy to the target material and heat it up.
- Heated material then vaporizes and forms plasma where its temperature is around 10,000K.
- The high energetic species ablated from the target are bombarding the substrate surface and may cause damage to the surface by sputtering off atoms from the surface.
- The sputtered species form the substrate and the particles emitted from the target form a collision region, for condensation of particles. When the condensation rate is high enough, the film grows on the substrate.
- The nucleation process and growth of crystalline film on a substrate depend on several factors such as the density, energy etc.

Why use a multijunction cell?

- If sunlight falls on a conventional silicon solar cell then most of the photons are not absorbed as they might have lower energy than band gap of semiconductor.

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization Volume 3, Special Issue 2, April 2014

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

- And only few photons are used in electron energizing process.

- To overcome this drawbackDifferent materials with different band gaps can be stacked to capture photons with a wider range of energies.

- It is so called because of the presence of more than one P-N junction due to the combination of more than one semiconducting material.

- In a multijunction solar cell, the material having higher band gap is placed on top and material having lower band gap is placed below it.

- The top junction captures high-energy photons, while others pass through to the lower-band-gap junctions below.

for example:

- If a material say 'X', which has a band gap of about 1.7 eV, could be layered with a material 'Y' of band gap of 0.7ev, then photons of energy greater than 1.7ev are absorbed on top layer and photons of energy from 0.7ev to 1.7ev will be absorbed in the bottom layers.

Procedure

- Rod shaped nanocrystals of two semiconductors are synthesized separately using the above stated methods.
- They are dissolved in a solution.

- They are deposited onto a conductive substrate using the pulsed laser deposition technique.

- Resulting film is thinner than hair.

Advantages

- Such cells obtained in the form of films show altered physical and chemical properties than their large grained counter parts.

- They are smaller than the conventional cells.

- Each Nanosized grain contains only about 900 atoms whereas the large grains contain nearly billions of atoms.

- For a given volume, the surface area of these cells is more than that of conventional cells. (surface area to volume ratio is high).

- They can absorb more light and of different wavelengths and there by increasing the efficiency of the cell.

CONCLUSION

- Thus by the use of nanotechnology principles we can decrease the thickness of solar cells and thereby increasing the surface area to volume ratio.

ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization *Volume 3, Special Issue 2, April 2014*

Second National Conference on Trends in Automotive Parts Systems and Applications (TAPSA-2014)

On 21st & 22nd March, Organized by

Sri Krishna College of Engineering & Technology, Kuniamuthur, Coimbatore-641008, Tamilnadu, India

- As the amount of raw material used is lowered, the cost of production also is decreased tremendously.
- Thus these nanosolar cells can be easily painted on the roofs of buildings, buses, cars etc. to harness the solar energy.

REFERENCES

1. P. G. DeGennes, *Scaling Concepts in Polymer Physics* (Cornell University Press, Ithaca, NY, 1979).
2. L. S. Lerman and H. L. Frisch, *Biopolymers* 21, 995 (1982).
3. O. J. Lumpkin and B. H. Zimm, *Biopolymers* 21, 2315 (1982).
4. T. T. Perkins, D. E. Smith, and S. Chu, *Science* 264, 819 (1994).
5. G. W. Slater and J. Noolandi, *Phys. Rev. Lett.* 55, 1579 (1985).
6. T. A. J. Duke, A. N. Semenov, and J. L. Viovy, *Phys. Rev. Lett.* 69, 3260 (1992).
7. T. A. J. Duke, J. L. Viovy, and A. N. Semenov, *Biopolymers* 34, 239 (1994).
8. G. F. Carle, M. Frank, and M. V. Olson, *Science* 232, 65 (1986).
9. E. M. Renkin, *Journal of General Physiology* 38, 225 (1954).
10. J. C. Giddings, *Unified Separation Science* (John Wiley & Sons, Inc, New York, NY, 1991).
11. R. E. Beck and J. S. Schultz, *Science*, 170, 1302 (1970).
    i. R. E. Beck and J. S. Schultz, *Biochimica et Biophysica Acta* 255, 273 (1972).