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RESEARCH ARTICLE

ENHANCING THE EFFICIENCY OF PHOTOVOLTAIC SOLAR CELL THROUGH CNT

*[1]Priti Shukla, [2]Bharat Gupta, [3]Kruti Shukla and [4]Satakshi Tiwari

[1]Professor, Technocrate Institute of Technology, Bhopal, India
[2]Professor, Technocrate Institute of Technology, Bhopal, India
[3]M.Tech Student, Electronic and Communication, SIRT, Bhopal
[4] Post Graduate Student, Electronic and Communication, Rutgers University, NZ, USA

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ABSTRACT

Carbon nano materials are superb materials for photovoltaic solar cells: they are Earth-abundant, possess high optical absorption, and better-quality thermal and photostability. Carbon, one of the few elements recognized since antiquity, holds outstanding potential as a material for solar cells. It's abundant in the Earth's crust (~0.2 wt. %), it can be found in Nature in its fundamental form as graphite, diamond and coal, and it is extensively used technologically with a production on documentation among other elements of 9 Gt/year. Nanostructured carbon allotropes have been intensively investigate in the history, including single–walled carbon nanotubes (SWCNT), fullerenes, grapheneand their chemical derivative. These materials grasp record values for physical properties essential for PV such as carrier mobility, mechanical strength, thermal conductivity and optical absorption, and are attractive for PV as they can be dissolve in organic solvents to deposit thin solar cell active layers from solution. Extra carbon allotropes such as amorphous carbon, nanodiamonds and graphene can be deposit in thin film form on flexible substrates using chemical vapor deposition.

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INTRODUCTION

Energy is the key input to drive and develop the life cycle. Mainly, it is the contribution of the nature to the mankind in various forms. The consumption of the energy is directly proportional to the improvement of the mankind. Today solar energy is being utilized for reducing our dependence on natural energy sources Due to the need to produce green sources of energy, there has been a keen awareness in finding solutions for improving efficiencies in solar cells. It is anticipated that the world will require to two times its energy supply by 2050. The most common cells in use commercially today are silicon-based solar cells (Green *et al.,* 2012). The high conversion efficiency (up to 25% in the lab), stability of high purity silicon, outstanding charge transport properties and the mature processing technologies have led to silicon dominating the photovoltaic (PV) market (Jiang and Yan, 2013). However, the manufacturing process of high efficiency silicon solar cells suffer from low throughput and thus these solar cells are costly, preventing silicon PV from contributing considerably as a source in the world's energy. Comparing to usual energy materials, carbon nanomaterials have unique size-/surface-dependent (e.g., morphological, electrical, optical, and mechanical) valuable properties for enhancing the energy-conversion (Liming Dai and Dong Wook change, 2012). Throughout the past 25 years or so, therefore, considerable efforts have been made to utilize the distinctive properties of carbon nanomaterials, as well as fullerenes, carbon nanotubes, and graphene, as energy materials, and incredible progress has been achieved in developing high-performance energy conversion (e.g., solar cells and fuel cells) and storage (e.g., supercapacitors and batteries) devices. This article reviews progress in the research and development of carbon nanomaterials for the period of the past twenty years or so for advanced energy conversion and storage, along with some discussions on challenges and perspectives in this exciting [Liming Dai, Dong Wook change, *et al*., 2012).

Corresponding author:* **Priti Shukla,
Professor, Technocrate Institute of Technology, Bhopal, India.

Carbon Nano Materials

Carbon is one of the majority plentiful elements in the earth's crust and is found in numerous structural forms (allotropes). Carbon atoms can be arranged in several ways to produce a wide variety of compounds that have unique and fascinating physical, chemical, and electronic properties. Carbon nanotubes (CNTs) are composed of hexagonally oriented carbon atoms with a cylindrical nanostructure (Iijima, S.

Helical, 1991). CNTs have been construct with enormously high length-to-diameter ratio (up to 132,000,000:1) (Oberlin *et al.,* 1976), which can be an important benefit for various applications including electronics, optics or sensing. CNTs are the strongest and stiff materials yet revealed in terms of tensile strength and elastic modulus, respectively. It has been shown that CNTs have a tensile strength 16 times high than stainless steel Carbon allotropes include fullerenes, carbon nanotubes, and graphene. Using a combination of these materials, it is possible to manufacture devices composed entirely of carbon-based components (Jeong and Jeong, 2011). Due to its abundance and ease of processing in solution, carbon-based devices can potentially be made economically and in large quantities. In addition, these materials show excellent electrical and optical properties, so they are highly tunable and can be used in many type of devices such as transistors, solar cells, displays, and super capacitors. Carbon devices can also have high chemical, thermal, and physical continued existence as compared to those made with other materials (Zhenan Bao and Michael Vogueritchian, 2013). CNTs can be classified into two types depending on the how many graphene layers they have. Nanotubes consisting of round roll of a single layer are called single-walled CNTs (SWCNTs) and where there are a number of rolled layers, these nanotubes are referred to as multi-walled CNTs (MWCNTs).

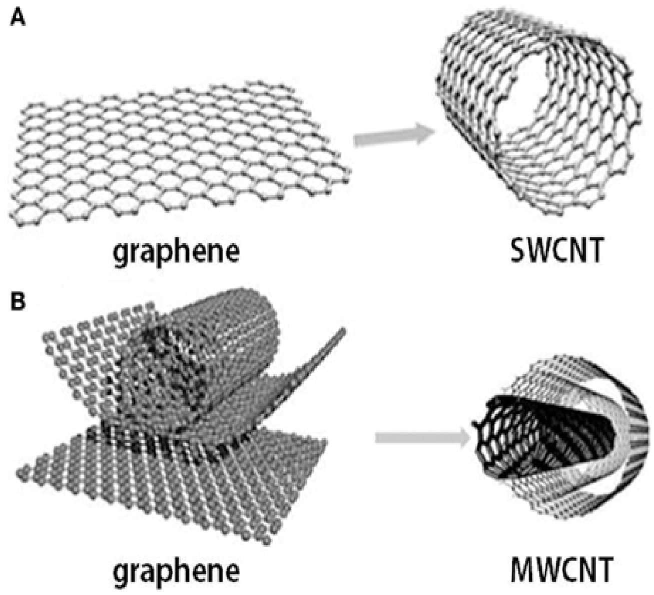

Fig. 1. Graphene and carbon nanotubes as [A] Single wall carbon nano tube (SWCNT) [B] Multi wall carbon nano tube (MWCNT)

In recent times researchers have particularly considered CNT silicon solar cells that were made-up by transferring a semi-transparent CNT film onto a n-type single crystalline Si wafer to form Schottky junctions and heterojunctions (Wei *et al.,* 2008). By applying a sequence of doping and gating methods such as $SOCl_2$ treatment (Jeong *et al.*, 2012), ionic liquid electrolyte infiltration and electronic gating (Wadhwa *et al.*, 2010) as well as nitric acid doping. Scientists have reported solar-cell devices with power conversion efficiencies (PCEs) of 0.1–1.3%. These solar cells consists of an all-carbon photoactive layer using semiconducting single-walled carbon nanotubes (SWNTs) as the light-absorbing component and charge-donating (donor) material, through a fullerene layer as the charge-accepting (acceptor) material (Bernardi and Lohrman, 2012). These reports established the potential of carbon-based materials as the active elements in a solar cell. However, these devices use regular electrodes, such as indium tin oxide (ITO) as the bottom electrode (anode) and silver or aluminum as the top electrode (cathode). These materials are costly, not solution processable, and not flexible—thus, they are not best choices.

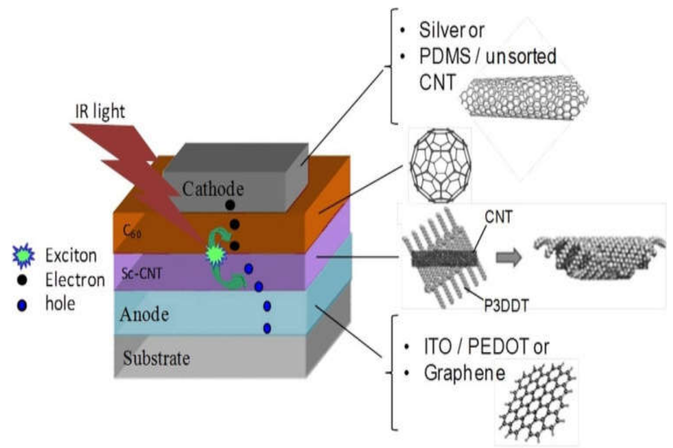

Figure 2. Structure of the carbon-based solar cell, showing the components of each layer and the process of electron-hole pair generation and separation when light is absorbed. Devices with both standard electrodes and carbon-based electrodes were fabricated. P3DDT and PEDOT are conductive polymers, while PDMS is a flexible silicone polymer. CNT: Carbon nanotube. ITO: Indium tin oxide. Sc-CNT: Semiconducting CNT. C_{60}: A fullerene

Nano solar cell with carbon nano tubes

The main problem in the usage of the solar cells is there deprived efficiency and high cost. The nano solar cells get rid of both the troubles, as the nano cells are have high efficiency and fewer costs as compare to the conventional solar cells. The efficiency has been improved by the execution of carbon nano tubes, which provides a impediment free path the electrons once it gets energy from the photons. As the elemental property of nano particle is well that, the number of free electrons on the nano particle surface is very high as compare to the micro particles. The cause being the surface area to the volume ratio is more in the case of nano particles. The tin oxide nano particles were prepared by conventional sol-gel method and the prepared nanoparticles with carbon nanotubes coated over the silica wafer to build PN junction. Lastly, with the aid of silver paste the electrode contact was taken. The very narrow structure of the nanotube forced the electrons to pass one by one, generate further electrons with the spare energy from the higher energy photons, in a nearly ideal energy adaptation process that could be the key in to higher efficiency solar panels The prepared nano solar cell has just about three times higher efficiency than the conventional solar cells hence it has the prospective to substitute the conventional solar cells.

Carbon nano tube based solar cell

Carbon nanotubes can be synthesized in several ways such as chemical vapor deposition or laser ablation. The natural ratio of as synthesized carbon nanotubes is 2/3 semiconducting to 1/3 metallic. Carbon-nanotube-based solar cells (CNSCs, Figure 3b).

CNSC offer many advantages beyond DSSCs.

- No Dye. As these cells utilize semiconducting CNTs for photo conversion, theydo not rely on dyes, which may bleach, severely restrictive the useful life of DSSCs.

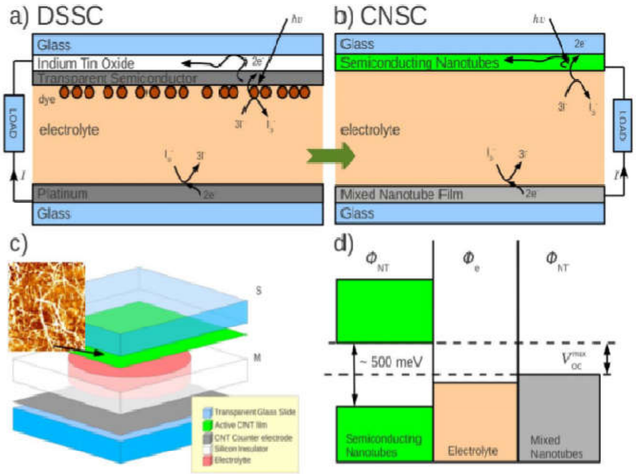

Figure 3. Comparison between a) Dye sensitized solarcell and b) Carbon nanotube solar cell construction c) Layout of CNSC and d) Band diagram of CNSC

- No Platinum. Pt is frequently used as counter electrodes and their use in DSSCs stand for an undesirable reliance on noble metals which may reduce the use of DSSCs on a large, i.e. utility, scale. In adding together, Pt has been reported to degrade due to the contact with the electrolyte [23]. Carbon nanotubes, in compare, are chemically inert, and in reality show promising characteristics as counter electrodes (Trancik *et al.,* (2008) & Ramasamy *et al.*(2008))
- No Indium. As the carbon nanotube film itself is a transparent conductor, the employ of a conducting coating made of, e.g. InSnO, is not necessary, eliminate the need for the exceedingly rare Indium (Hwang *et al.*, 2007; Kang *et al.*, 2010).
- The submission of carbon nanotubes to the glass slides is a low temperature spray-coating process. In addition, these CNSCs increase the advantages offered by DSSCs above single and multi-junction solar cells that need high-grade semiconductors and clean-room manufacturing. The utilize of low grade materials and resulting projected noteworthy reduction in cost of manufacturing potentially offset the limited efficiency of these cells when relating the energy produced per dollar spent in manufacturing and installation.

Efficiency

The average solar flux for the duration of testing was 770 W/m^2, and the greatest solar power generation was attain with the graphite counter electrode and enriched medium-density CNT active electrode. The efficiency of that cell was 1.8 X 10^5. compare to the all-CNT construction, an enhancement of more than a factor 10 was attained. If a cell were construct with the graphite counter electrode and the low-concentration CNT enriched lively electrode, an increase of power by a factor 2 is expected. This can be deduce by comparison of the medium density enriched cell to the low density enriched cells with the usual construction (Zhou *et al.,* 2006) As the graphite counter electrode lower the output resistance by a factor ~ 3, the power output might be larger by a factor 3 as well. Further improvement may be obtain by changing the aspect ratio of the solar cell. In the design report here, we use effectively square films. Changing the cell design by building the cells wider, will lower the resistance further. An aspect ratio of 10 can then decrease the film resistance by a factor of 10, causing a decrease of Rmax, which will improve Pmax. Our thin cell results designate that the largest resistance is due to the nanotube film, we therefore suppose the efficiency increase with this enhancement may be as large as 10-fold. We suppose the greatest efficiency increase may be obtained by using CNT basis material with a superior fraction of semiconducting nanotubes (Tans *et al.,* 1998).

Conclusion

CNTs are outstanding materials for sunlight absorption and to produce photocarriers. In addition, CNTs can transfer electrons or holes efficiently and show good PV property. As a transparent electrode CNTs are very capable due to their good conducting property, low resistivity and flexibility. This effort established for the first time that a heterojunction photovoltaic cell can be produced using CNTs as a conductive scaffolding coated with semiconducting materials. The p/n-type materials created a coating that is adherent and conformal.

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