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Carbon Nanotubes in Solar Panel Technology

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***Abstract* — This paper introduces the advancement in the solar panel technology. It gives information about the usage of the carbon nanotubes or graphite instead of silicon in solar panels. These carbon nanotubes are used for photo conversion and a counter electrode construction, which are placed in liquid electrolyte through a (reduction and oxidation) redox reaction. The silicon semiconductors are prepared to take infrared light in solar cells and directly convert electricity. Meantime, the visible spectrum is lost as heat and longer wavelengths pass through unexploited. A new nano-material act as a thermal emitter being developed by a group of researchers spread across the country making solar power significantly more efficient by scooping up more of that wasted energy. The infrared part of light is relatively convenient for conventional high-efficiency solar cells to convert to electricity, and the thermal emitter perspective works within that framework. For deriving electricity directly from the sun's rays, thermal emitter is not a parallel system. Instead, this is an application or so called thermos photovoltaic principals. Researchers have estimated a theoretical 80% efficiency rating — much higher than the mid-30s where most silicon-based solar panels are stuck.**

***Key Words* — Solar panels, Carbon nanotubes, Photovoltaic principals, Thermal emitter, SWNT, MWNT.**

I. INTRODUCTION

Humanities biggest problems are energy and environment. This is because of sudden increase in population and limited source of energies are available on earth. So one of the best option to avoid energy crises is use of solar energy because the earth receives more energy from the sun is just one hour than the worlds uses in a whole year. But today's solar panel has low efficiency and high cost. So introduction of carbon nanotubes in solar panel technology by using solar energy will help us to eliminate this problem.

The need for power in remote locations has given rise to the need for more portable solar cell. Great potential for the solution have been shown by the organic solar cells. The problem of insufficient efficiency currently found in organic solar cells. There is more to solar radiation than meets the eyes: Sun-burn evolves from invisible UV radiation, while we sense infrared radiation as heat on our skin, although it is invisible to us. Solar cells only see a part of solar radiation: about 20 percent of the energy contained in the solar spectrum is unavailable to cells made of silicon – they are unable to use infrared radiation, and part of short wavelength IR radiation, for generating power.

Carbon nanotubes are wires of pure carbon with nanotubes diameters and lengths of many microns. A singled-walled carbon nanotubes (SWNT) may be thought of as a single atomic layer thick sheet of graphite (called grapheme) rolled into a seamless cylinder. Multi-walled carbon nanotubes (MWNT) of several concentric nanotubes shells.

II. LITERATURE SURVEY

In this paper, carbon nanotubes in solar panel technology, g. narayanamma institute of technology and science, yenigall. srujana, k. shoushya, k. sowmya studied that today's solar panel has low efficiency and high cost. So introduction of carbon nanotubes in solar panel technology by using solar energy will help us to eliminate this problem. The science and technology of carbon nanotubes, (1999) Elsevier, eds. k. tanaka, t. yamabe and k. yamabe, carbon nanotubes survey presented the unique atomic structures, properties and application of carbon nanotubes. The electrical, mechanical and thermal properties of CNTs are primarily dependent on their diameter and chirality.

The Science and Technology of Carbon Nanotubes, (1999) Elsevier, Eds. K. Tanaka, T. Yamabe and K. Yamabe studied that Carbon nanotube (CNT) is the name of ultrathin carbon fiber with nanometer size diameter and micrometer-size length and was accidentally discovered by a Japanese scientist, Sumio Iijima, in the carbon cathode used for the arc discharging process preparing small carbon clusters named by fullerenes. It seems that a considerable number of researchers have been participating into the science of CNTs and there has been remarkable progress in the both experimental and theoretical investigations on MWNT and SWNT particularly during the last couple of years.

III. CURRENT SOLAR TECHNOLOGY AND THEIR DISADVANTAGES

There are two types of conventional solar cells called as first generation and second generation solar cells. The first generation is made up of silicon wafers. By using crystalline solar cells, it is theoretically possible to convert nearly 29 percent of the light into energy. Single crystals silicon wafers are effective in the commercial production of solar cells. They consist of a large area, single layer p-n junction. But most of photon energy is wasted as hest and required expensive manufacturing technologies. Many of the leading firms make both mono crystalline and poly crystalline solar cells for their panels. It was the first solar panel in market. Polycrystalline panels have a lower efficiency than mono-crystalline solar cells.

The next step was the second generation thin filmed photovoltaic panels made of amorphous silicon, and two that are made from non-silicon materials namely cadmium telluride (CDTe), and copper indium gallium selenide (CIGS). The production methods are complex, but less energy intensive then crystalline solar panels, and prices have been coming down as panel are mass-produced using this process.

The third generation of solar cells is being made from variety of new materials beside silicon, including nanotubes, silicon wires, and solar inks using conventional printing press technologies, organic dyes, and conductive plastics. The aim is to improve commercially available- by making solar cell energy more efficient over a wider band of solar energy (e.g. including infrared), less expensive so it can be used by more and more people, and to develop more and different uses.

IV. History Of Cnt Solar Panels

Carbon nanotubes were invented in 1991 by the Japanese electron microscopist SUMIO IIJIMA Laboratory in Tsukuba used high resolution transmission carbon nanotubes, and into the awareness of the scientific community. Iijima's discovery of multi walled carbon nanotubes in the insoluble material of arc burned graphite rods in 1991 and mint mire, Dunlap and white's independent prediction that if singled walled carbon nanotubes could be made, then they would exhibits remarkable conducting properties helped create the initial buzz that is now associated with carbon nanotubes. Stanford University scientists have built the first solar cell made entirely of carbon, a promising alternative to the expensive materials used in photovoltaic devices today.

IV. Solar Panel

A Set of solar photovoltaic modules electrically connected and mounted on a supporting structure is known as solar panel. A photovoltaic module is a packaged, connected assembly of solar cells. To generate and supply electricity in commercial and residential applications, the solar panel can be used. Under standard test conditions (STC), each solar module is rated by its DC output power and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. A single solar module can generates only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring.

Fig.1.An Installation of 24 solar modules in rural Mongolia

VI. Carbon Nanotubes

Carbon nanotubes (CNTs) are allotropes of Carbon with a cylindrical nanostructure. Nanotube has been constructed with length-to-diameter ratio of up to 132,000,000:1, significantly larger than for any other material. An unusual property of carbon nanotubes is important for nanotechnology, electronics, optics and other fields of technology. In particular, in consideration of their extraordinary thermal conductivity and mechanical and electrical properties, carbon nanotubes find applications as additives to various structural materials. For instance, nanotubes form a very small portion of the material(s) in some (primarily carbon fiber) baseball bats, golf clubs, or car parts. These carbon nanotubes are now used in the technology of solar panels to increase the efficiency of the solar panels up to 80%. The disputation mentioned ahead will help in understanding how these carbon nanotubes can be used in solar panels. There are two types of carbon nanotubes

- Single walled carbon nanotubes
- Multi walled carbon nanotubes

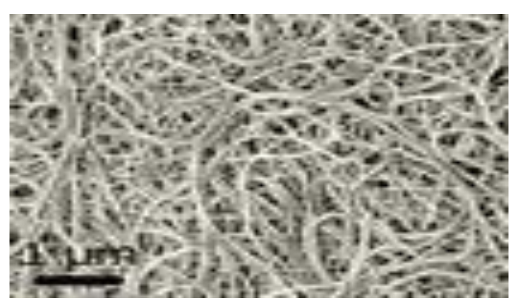

Fig.2: A scanning electron microscopy image of carbon Nanotubes bundles

A. Single Walled Carbon Nanotubes

A single walled carbon nanotubes (SWNT) is made from single atomic layer thick sheet of graphite (called graphene) rolled into a seamless cylinder. Most single walled carbon nanotubes (SWNT) have a diameter of close to 1 nanometer with a tube length that can be many millions of times longer. Single walled nanotubes are an important variety of carbon nanotubes because they exhibit electric properties that are not shared by the multi walled carbon nanotubes (MWNT) variants.

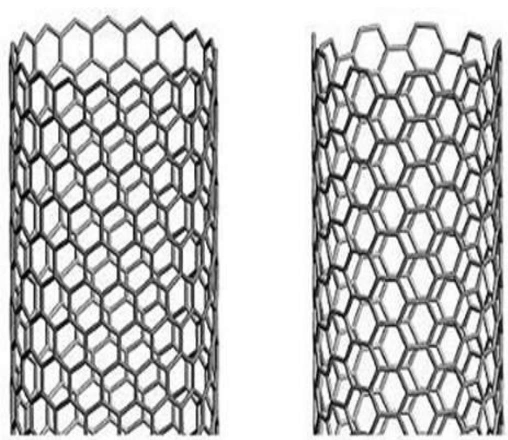

Fig.3: Single Walled Carbon Nanotubes

B. Multi Walled Carbon Nanotubes

Multi walled nanotubes (MWNT) consist of multiple rolled layers (Concentric tubes) of graphite. The multi walled nanotubes can be described by the two models. In the Russian Doll model, sheet of graphite are arranged in concentric cylinders. In the Parchment model, a single sheet of graphite is rolled in around itself, resembling a scroll of parchment or a rolled newspaper. (The Russian Doll structure is observed more commonly). The telescopic motion ability of inner shells and their unique mechanical properties will permit the use of multi walled nanotubes as main movable arms in coming nano mechanical devices.

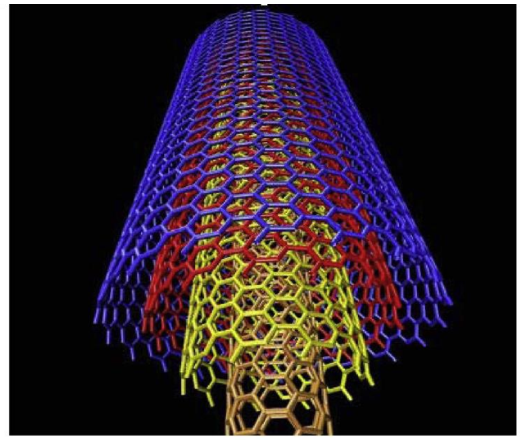

Fig.4: Multi Walled Carbon Nanotubes

VII. Working Of Carbon Solar Panel

Solar panels works on the principal of photovoltaic effect. Photovoltaic effect is the creation of an electrical voltage or rather the electric current flows in a closed loop, here referred to in a solar panel. This process is somewhat related to the photoelectric effect. When the solar panels are exposed to a stream of photons these generated electrons are transferred between the different bands of energy inside the atom to which they are bound. Typically, the transition of the energy state of electrons takes place from valence band to the conduction band, but within the material that is used in the solar panels. This transfer of electrons makes them developed in order to cause a buildup of voltage between the two electrodes. The double-walled carbon nanotubes are directly configured as energy conversion materials to fabricate thin-film solar panel, with nanotubes serving as both photo generation sites and a charge carriers collecting/transport layer. The solar cells consist of a semi-transparent thin film of nanotubes conformably coated on n-type crystalline silicon substrate to create high-density p−n heterojunctions between nanotubes and n-Si to favor charge separation and extract electrons (through n-Si) and holes (through nanotubes). Initial tests have shown a power conversion efficiency of >1%, proving that DWNTs-on-Si is a potentially suitable configuration for making solar cells. Our devices are distinct from previously reported organic solar cells based on blends of polymers and nana materials, where conjugate polymers generate exactions and nanotubes only serve as a transport path.

Material	Thermal Conductivity	Electrical conductivity
Carbon Nanotube	>3000	10^6 – 10^7
Copper	400	6*10^7
Carbon Fiber - Pitch	1000	2 – 8.5*10^6
Carbon Fiber - PAN	8 – 105	6.5 – 14*10^6

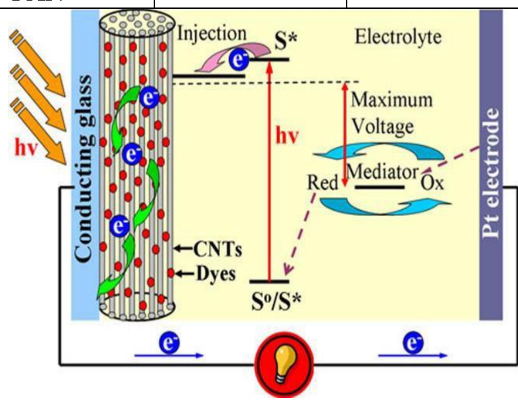

Fig.5: working of Carbon solar panel

VIII. Advantages of Using CNT in a Solar Panel

- The efficiency of the system can be improved.
- As the CNT solar panels use infrared rays including visible range of sunlight, they can work at night times.
- They remain stable at ambience temperature about 1600 F.
- The amount of the material to be used for the construction will also be reduced.
- As the mobility of the electrons is more in the case of the CNT the output voltage produced is drastically increased.

IX. Nanotube Properties Useful For Solar Panels

• High carrier mobility's (~1, 20,000 cm2 V-1 s-1)
• Large surface areas (~1600 m^2 g^{-1})
• Absorption in the IR range (E.g.: 0.48 to 1.37eV)
• Conductance - Independent of the channel length
• Enormous current carrying capability – 109 A cm-2
• Semiconducting CNTs – Ideal solar cells
• Mechanical strength & Chemical stability

Table- 1. Properties of conductive materials

X. Performance Of CNTs

Instead of the pure polymer substances, CNT is used and the performance of the solar cell is as shown below:

The V-I characteristics shows the linear variation of the output produced in the process of conversion of the light energy into electrical energy.

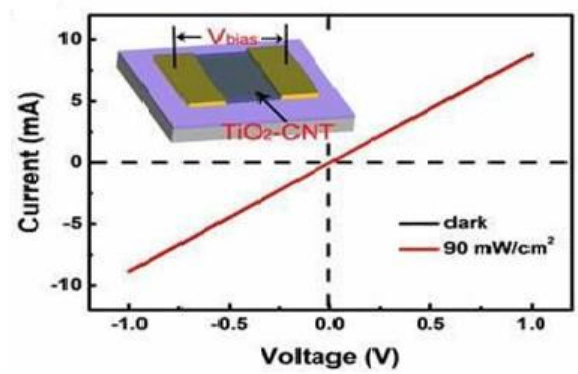

Fig.6: Performance of the carbon solar panel depending on the light emission of the singled walled carbon nanotubes.

The graph shows the variation of the wavelength and light energy which is inputted to the panel with the transmittance of that energy.

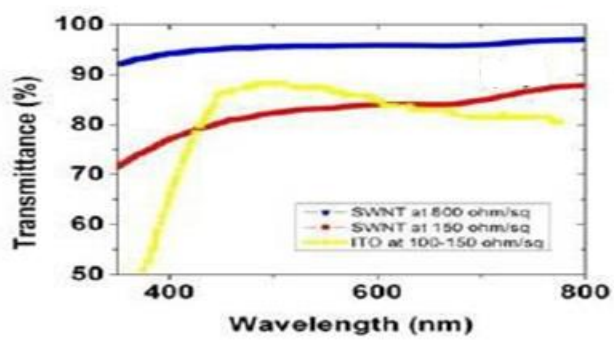

Fig.7: Variation of the wavelength over percentage transmittance

Conclusion

Upcoming carbon nanotubes technology is in the field of solar panels is under experimental stage. This looks like a very promising direction which ultimately promises to tap more for the nanotubes. It is useful in increasing the efficiency, reliability of the solar panel.

Recently nanotubes membranes have been developed for used in filtration. Due to this technique, the perceived low desalination costs can be 75%. The tubes are designed such that small particles (like water molecules) can pass through them, while larger particles (such as the chloride ions in salt) are blocked.

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