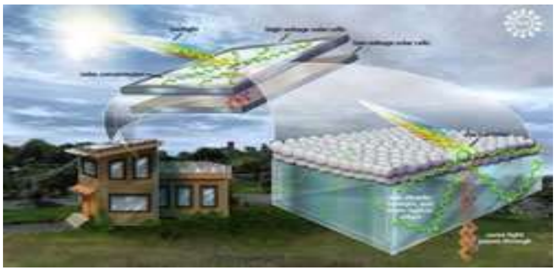
EFFICIENT METHOD FOR SOLAR ENERGY HARVESTING & STORAGE USING THIN FILM CARBON- NANO TUBES

[1] S.Karthikeyan [2] M.Mano
[1,2]*Department of Electronics and Instrumentation Engineering*
M.Kumarasamy College of Engineering, Karur, Tamilnadu, India
[1]*skarthik.me@gmail.com*
[2]*manom.eie@mkce.ac.in*

Abstract: This paper will gives a thorough insight of this relatively revolutionizing and satisfying solution of energy harvesting and storage through carbon nanotube by using thin film technology. In today's world one of the major problems faced by almost all the countries around the world is energy crisis. Although there are several ways of producing electrical energy from the available sources of energy, still it is not sufficient to satisfy the energy need of the world completely. From the most commonly available source of energy (solar energy), electrical energy has been produced using some traditional techniques, which is of the range of very few units of energy. Let us replace this conventional technique with most emerging method of solar energy conversion method using infrared solar nano cells integrated with carbon nano tubes for efficient storage of those converted energy. One of the most possible methods of using this nano cells is in the form of nano paints. Nano cells which has the capability to convert even small amount of incident light into electrical energy rather than requiring certain range of intensity. This technique replaces the bulky structure of conventional solar panels because of the size of nano cells. **This paper also includes the efficient storage using carbon nano tubes in the form of super capacitors and paper batteries.** This paper is aimed at understanding and analysing the implementation of infrared solar nano cells, its properties, characteristics and its potential in practical application .This paper is also aims at highlighting the construction and practical implementation paper batteries and super capacitors.

INTRODUCTION:

Nanotechnology is at the core of today's efforts to develop what many refer to as solar paint. Some recent developments have advanced the technology and provide a glimpse into the potential benefits solar paint might one day deliver .Solar cells based on solar paint will likely offer a trade-off in performance versus cost. Solar paint-based cells are expected to have fairly low solar conversion efficiency rates. Perhaps in the single digit range at best. Currently, the highest touted efficiency rates for small experimental samples are in the six percent range. That is significantly lower than today's best photovoltaic cells, which deliver in the low to mid-20 percent efficiency. However, the thinking is that a solar paint based approach will offer cost savings in several areas, thus making them more attractive. Many of the solar paint technologies being developed today would offer lower manufacturing costs. The materials could (theoretically) be applied under more common conditions such as at room temperature in an ordinary facility. This would yield be a much lower cost than using clean rooms and silicon fabrication facilities, as is needed to produce the current generation of photovoltaic solar cells. This energy may be efficiently stored by the paper batteries and super capacitors. No doubt, this technology holds the light of human future



How thin film solar nano cells are made possible:

Titanium dioxide nano particles are coated with CdS or CdSe. The composite nano particles, when mixed with a solvent, form a paste that can be applied as one-step paint. It typically takes a day or two to prepare quantum dot solar cells in the conventional multifilm architecture. Now a team of researchers is reducing the preparation time of quantum dot solar cells to less than an hour by changing the form to a one-coat quantum dot solar paint. Although the paint form is currently about five times less efficient than the highest recorded efficiency for the multifilm form, the researchers predict that the efficiency can be improved, which could lead to a simple and economically viable way to prepare solar cells The new solar paint, which the researchers humorously call "Sun Believable solar paint," consists of a yellow or brown paste made of quantum dots. The small size of these tiny semiconductor nanocrystals makes it possible to capture nearly all incident visible sunlight with an extremely thin layer of dots. The researchers experimented with three types of quantum dots: CdS, CdSe, and TiO2, all of which are powder-like, with water and tert butanol as the solvent. All commercial paints are TiO2 nanoparticle-based suspensions. But instead of adding dye to give the paint a desired colour, here the researchers added coloured semiconductor nanocrystals to the solar paint to achieve the desired optical and electronic properties. "Quantum dots are semiconductor nanocrystals which exhibit size-dependent optical and electronic properties. In a quantum dot sensitized solar cell, the excitation of semiconductor quantum dot or semiconductor nanocrystal is followed by electron injection into TiO2 nanoparticles. These electrons are then transferred to the collecting electrode surface to generate photocurrent. The holes that remain in the semiconductor quantum dot are removed by a hole conductor or redox couple and are transported to a counter electrode While preparing a quantum dot film as a solar cell usually requires multiple time-intensive steps, solar cells in paint form can simply be brushed on to a surface in one step." a composite of mixed CdS/TiO2 and CdSe/TiO2 nanoparticles achieve the best performance, particularly when the CdS and CdSe are deposited directly on the TiO2 nanoparticles as a coating. When coated on a glass electrode, the paint has an overall power conversion efficiency exceeding 1%. Although some multifilm quantum dot solar cells have efficiencies greater than 5%, the researchers think that using different quantum dots and further optimization could significantly increase the efficiency of the paint. “Careful control of particle size and better electron transport through TiO2 network should enable us to maximize the efficiency, it is necessary extend the absorption range to near IR by using semiconductors such as PbS and PbSe. The new solar paint is the first step toward developing a solar technology that could potentially have wide-ranging applications. Some uses could include painting electronic devices such as cell phones and computers, in addition to rooftops, windows, and cars.

WHAT IS A PAPER BATTERY?

Introduction:

A paper battery is flexible, ultra-thin energy storage and production device formed by combining carbon nanotubes with a conventional sheet of cellulose based paper. A paper battery acts as both a high-energy battery and super capacitor, combining two discrete components that are separate in traditional electronics.

Paper Battery=Paper (Cellulose) + Carbon Nanotubes

Cellulose is a complex organic substance found in paper and pulp; not digestible by humans. A Carbon NanoTubes (CNT) is a very tiny cylinder formed from a single sheet of carbon atoms rolled into a tiny cylinder. These are stronger than steel and more conducting than the best semiconductors. They can be Single-walled or Multi-walled.

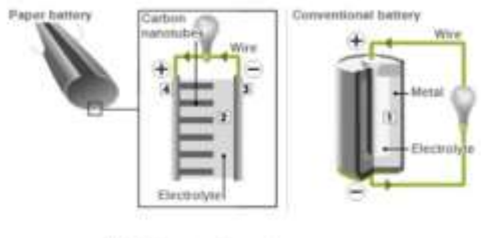


Fig 3.2 Structure of a paper battery

Properties of Paper Batteries:

The properties of Paper Batteries are mainly attributed to the properties of its constituents.

Properties of Cellulose:

- High Tensile strength; Low Shear Strength
- Biodegradable
- Biocompatible
- Excellent Porosity & Absorption Capacity
- Easily Reusable and Recyclable
- Non –Toxic

Properties of Carbon Nanotubes:

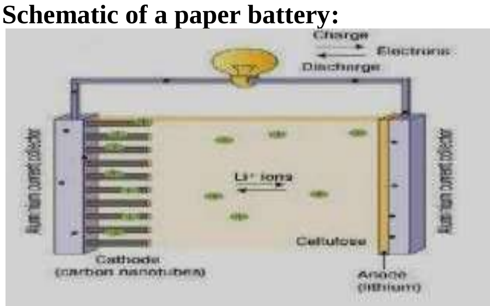
- Ratio of Width: Length: 1:107
- High tensile Strength (Greater than Steel).
- Low Mass density & High Packing Density.
- Very Light and Very Flexible.
- Very Good Electrical Conductivity (better than Silicon).
- Low resistance (~33 ohm per sq. inch).
- Output Open Circuit Voltage(O.C.V): 1.5-2.5 V (For a postage stamp sized Specimen)
- The O.C.V. of Paper Batteries is directly proportional to CNT concentration.
- Stacking the Paper and CNT layers multiplies the Output Voltage; Slicing the Paper and CNT layers divides the Output Voltage.
- Thickness: typically about 0.5-0.7mm.
- Nominal continuous current density: 0.1 mA/cm2/ active area.
- Nominal capacity: 2.5 to 5 mAh/cm2/ active area.
- Shelf life (RT): 3 years.
- Temperature operating range: -75°C to +150°C.
- No heavy metals (does not contain Hg, Pb, Cd, etc.)
- No safety events or over-heating in case of battery abuse or mechanical damage
- No safety limitations for shipment, packaging storage and disposal.

Construction and Working

A very brief and concise explanation has been provided.

- Cathode: Carbon Nanotube (CNT)
- Anode: Lithium metal (Li+)
- Electrolyte: All electrolytes (incl. bio electrolytes like blood, sweat and urine)
- Separator: Paper (Cellulose)

Schematic of a paper battery:



The process of construction can be understood in the following steps:

- Firstly, a common Xerox paper of desired shape and size is taken.
- Next, by conformal coating using a simple Mayer rod method, the specially formulated ink with suitable substrates (known as CNT ink henceforth) is spread over the paper sample.
- The strong capillary force in paper enables high contacting surface area between the paper and nanotubes after the solvent is absorbed and dried out in an oven.

• A thin lithium film is laminated over the exposed cellulose surface which completes our paper battery. This paper battery is then connected to the aluminum current collectors which connect it to the external load.

• The working of a paper battery is similar to an electrochemical battery except with the Constructional differences mentioned before the procedure.

Advantages over existing batteries:

1. Biodegradable & Non Toxic: Since it's major ingredients are of organic origin, it is a biodegradable and non-toxic product.
2. Biocompatible: They are not easily rejected by our body's immune system if implanted into Human body.
3. Easily Reusable & Recyclable: Being cellulose based product it is easily recyclable and reusable, even with the existing paper recycling techniques.
4. Durable: It has a shelf life of three years (at room temperature). Under extreme conditions it can operate within -75° to +150°C.
5. Rechargeable: It can be recharged up to 300 times using almost all electrolytes, including Bio-salts such as sweat, urine and blood.
6. No Leakage & Overheating: Owing to low resistance, it does not get overheated even under extreme conditions. Since there are no leaky fluids, so even under spontaneous or accidental damage, there is no leakage problem.
7. Very Light Weight & Flexible.
8. Easily Moldable Into Desired Shapes & Sizes.
9. Customizable Output Voltage:

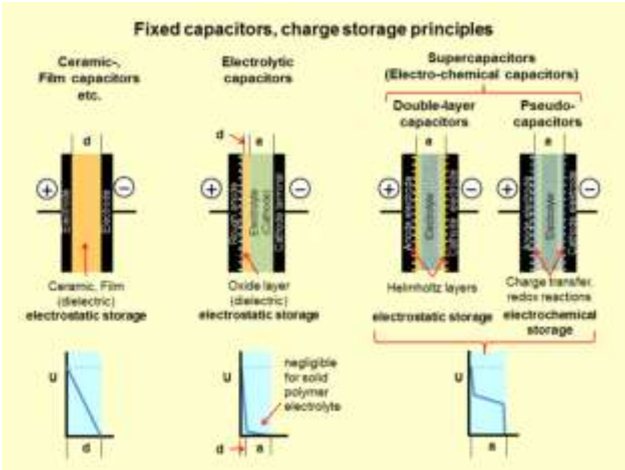
• By varying CNT concentration.

• By stacking & slicing.

SUPER CAPACITOR:

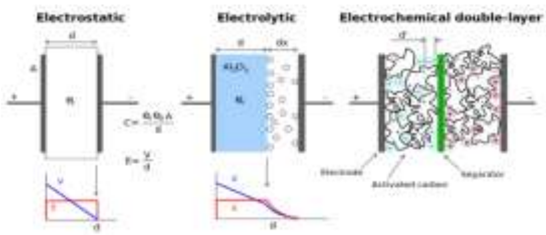
Super capacitor also known as electric double-layer capacitor (EDLC), super condenser, pseudo capacitor, electrochemical double layer capacitor, or ultra-capacitor, is an electrochemical capacitor with relatively high energy density. Compared to conventional electrolytic capacitors the energy density is typically on the order of hundreds of times greater. In comparison with conventional batteries or fuel cells, EDLCs also have a much higher power density.

In this article the use of super capacitors likes hybrid power supply for various applications is presented. The main application is in the field of automation. The specific Power of the super capacitors and its high lifetime (1 million of Cycles) makes it very attractive for the start up of the automobiles. Unfortunately, the specific energy of this component is very low. For that this technology is associated with battery to supply the starter alternator.



Introduction of Super Capacitor

Super capacitors also known as Electric double-layer capacitors, or electrochemical double layer capacitors (EDLCs), or ultra-capacitors, are electrochemical capacitors that have an unusually high energy density when compared to common capacitors, typically on the order of thousands of times greater than a high capacity electrolytic capacitor. For instance, a typical electrolytic capacitor will have a capacitance in the range of tens of mill farads. The same size super capacitor would have a capacitance of several farads, an improvement of about two or three orders of magnitude in capacitance but usually at a lower working voltage. Larger, commercial electric double layer capacitors have capacities as high as 5,000farads.



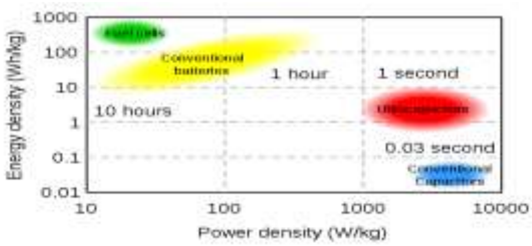
In a conventional capacitor, energy is stored by the removal of charge carriers, typically electrons, from one metal plate depositing them on another. This charge separation creates a potential between the two plates, which can be harnessed in an external circuit. The total energy stored in this fashion increases with both the amount of charge stored and the Potential between the plates. The amount of charge stored per unit voltage is essentially a function of the size, the distance, and the material properties of the plates and the material in between the plates (the dielectric), while the potential between the plates is limited by breakdown of the dielectric. The dielectric controls the capacitor's voltage. Optimizing the material leads to higher energy density for a given size of capacitor.

EDLCs do not have a conventional dielectric. Rather than two separate plates separated by an intervening substance, these capacitors use "plates" that are in fact two layers of the same substrate, and their electrical properties, the so-called "electrical double layer", result in the effective separation of charge despite the vanishingly thin (on the order of nanometres) physical separation of the layers. The lack of need for a bulky layer of dielectric permits the packing of plates with much larger surface area into a given size, resulting in high capacitances in practical-sized packages.

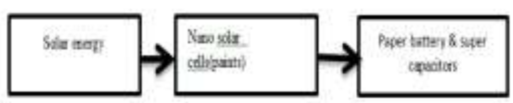
Super capacitor technology is based the electric double layer phenomenon that has been understood for over a hundred years. However, it has only been exploited by commercial applications for about ten years. As in a conventional capacitor, in an ultra-capacitor two conductors and a dielectric generate an electric field where energy is stored. The double layer is created at a solid electrode-solution interface - it is, then, essentially a charge separation that occurs at the interface between the solid and the electrolyte. Two charge layers are formed, with an excess of electrons on one side and an excess of positive ions on the other side. The polar molecules that reside in between form the dielectric. In most ultra-capacitors, the electrode is carbon combined with an electrolyte. The layers that form the capacitor plate's boundaries, as well as the small space between them, create a very high capacitance. In addition, the structure of the carbon electrode, which is typically porous, increases the effective surface area to about 2000 m2/g.

ADVANTAGES:

Super capacitors which has high storage density per volume than any other capacitors. Super capacitors which has the capability to store energy of several farads (12,000 farads) whereas of conventional capacitors with range of very few farad range. This paper mainly aims at the implementation of this effective technique for conventional use and gives its various advantages over the techniques used today in terms of its construction, properties, and size.



HOW THIS STUFF IS GOING TO WORK:



Sun is the source of energy for all things in this world. The nano cells which are usually nano paints trap the solar energy. Here we use infrared nano solar cells which have the ability to trap or harvest solar energy in the mere presence of sun, even though in cloudy days because we are going to use solar cells which are highly sensitive to infrared rays from sun. The harvested energy from the sun is stored in paper battery and in super capacitors. The paper battery and super capacitor are both belong to thin film carbon nano tubes which have slight variation in their manufacturing process. With the help of this we can store a large amount of energy as super capacitor stores energy in order of hundreds of farads and paper battery is also enhance the amount of energy stored to a greater extent. This stored energy can be utilized directly for the human needs.

DISADVANTAGES:

It would not be logical only to ponder over the miraculous properties and applications of Paper batteries, solar nano cells as well as super capacitors .Things need to be discussed at the flip side as well. Following are some of them

There could also be problems with cycling, or the number of times the same device can be charged and discharged without losing power. It is not sure its performance would match other things currently available in the market, due to significant capacity fade upon cycling.

It would not be logical only to ponder over the miraculous properties and applications of Paper Batteries .Things need to be discussed at the flip side as well. Following are some of them:

• Have Low Shear strength: They can be ‘torn’ easily.

• The Techniques and the Set-ups used in the production of Carbon Nanotubes is very expensive and very less Efficient. These are:

(i)Arc discharge

(ii)Chemical Vapour Deposition (CVD)

(iii) Laser Ablation

(iv)Electrolysis

• When inhaled, their interaction with the Microphages present in the lungs is similar to that with Asbestos fibers, hence may be seriously hazardous to human health.

RESULTS AND CONCLUSION:

One of the major problems bugging the world now is Energy crisis. Every nation needs energy and everyone needs power. And this problem which disturbs the developed countries perturbs the developing countries like India to a much greater extent. Standing at a point in the present where there can’t be a day without power. This system can provide an altogether path-breaking solution to the same. Being Biodegradable, Light-weight and Nontoxic, flexible system has potential adaptability to power the next generation of electronics, medical devices and hybrid vehicles, allowing for radical new designs and medical technologies. Again we want to conclude that this system hold the light for the future.

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