International Journal of Electronics and Electrical Engineering

Volume 1 | Issue 2 Article 5

October 2012

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Recommended Citation

ISLAM, MD. NIZAMUL; CHOUDHURY, NAWSHAD UDDIN AHMED; HOQ, MD. TANVEER; and KABIR, TASHFIQ HOQUE SAIF (2012) "CARBON NANOTUBE: IMPLEMENTATION OF CARBON NANOTUBE IN SUPERCAPACITOR," *International Journal of Electronics and Electrical Engineering*: Vol. 1 : Iss. 2 , Article 5.
DOI: 10.47893/IJEEE.2012.1019
Available at: https://www.interscience.in/ijeee/vol1/iss2/5

CARBON NANOTUBE: IMPLEMENTATION OF CARBON NANOTUBE IN SUPERCAPACITOR

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Abstract-**This paper deals with the implementation of carbon nanotube as electrode in supercapacitor to store much more energy .the author also consults with the problem may face and try to resolve the problems.**

Keywords: Super capacitor, Activated carbon, Carbon nanotube, Electrode, Electrolyte

1. INTRODUCTION

In response to the changing global landscape, energy has become a primary focus of the major world powers and scientific community. There has been great interest in developing and refining more efficient energy storage devices. One such device, the supercapacitor, has matured significantly over the last decade and emerged with the potential to facilitate major advances in energy storage. Supercapacitors, also known as ultracapacitors or electrochemical capacitors,utilize high surface area electrode materials and thin electrolytic dielectrics to achieve capacitances several orders of magnitude larger than conventional capacitors . In doing so, supercapacitors are able to attain greater energy densities while still maintaining the characteristic high power density of conventional capacitors. Batteries are most common form of energy storage device,but it has some limitations which encourage the use of supercapacitor. Battery can store large amount of energy but it can deliver less power than conventional capacitors.

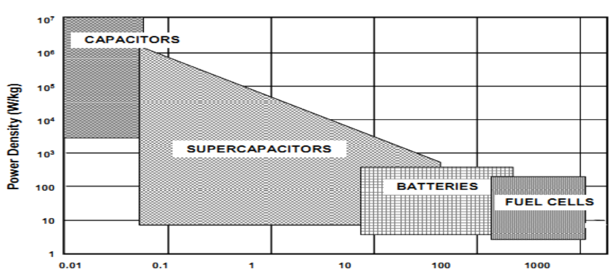

Figure 1: Ragone plot

From figure 1 it is clear that supercapacitor has both high energy density & power density than any other storage devices.

There are many advantages of supercapacitor over battery.There are chemical reaction in the battery device for which rechargeable battery lifecycle is not more than 1000 cycles.In case of supercapacitor there are no chemical reaction .so it's lifecycle is 10000000 times more than battery.Dielectric materials which is necessary for capacitor is not needed in supercapacitor.

Supercapacitor is used in many applications.Most importantly many telecommunication industry,power industry,Aerospace and military applications are using supercapaciyor in various important purpose.Though supercapacitor is used in many fields but in some cases it is needed more energy density in same size of supercapacitor.on that purpose Carbon Nanotube(CNT) is used in electrode to increase energy density of supercapacitor.The Ready group at Georgia Tech has worked with NASA and the Space and Missile Defense Command (SMDC) to develop CNT-based supercapacitors since 2003.Supercapacitor incorporating CNTs can increase energy storage than conventional capacitors and Batteries with equivalent amount of delivered power.

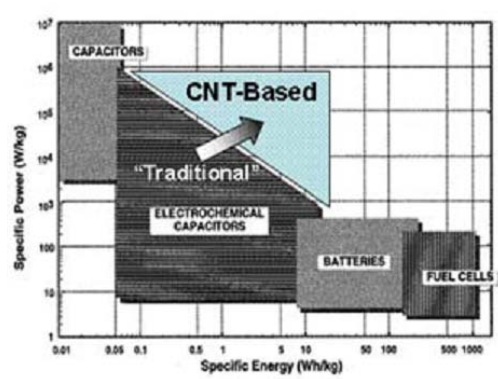

Figure 2:Plot of Specific power versus specific energy of different storage devices

Many companies like Maxwell,Epcos,Panasonic etc are manufacturing large sizes(>5000F) devices.In this paper we will discuss CNT based supercapacitor to enhance energy storage.

1. OVERVIEW OF CARBON NANOTUBE

They take the form of cylindrical carbon molecules and have novel properties that make them potentially useful in a wide variety of applications in nanotechnology, electronics, optics and other fields of materials science.They exhibit extraordinary strength and unique electrical properties, and are efficient conductors of heat.Inorganic nanotubes have also been synthesized. Nanotubes are members of the fullerene structural family, which also includes buckyballs.Whereas buckyballs are spherical in shape, a nanotube is cylindrical, with at least one end typically capped with a hemisphere of the buckyball structure.Their name is derived from their size, since the diameter of a nanotube is on the order of a few nanometers (approximately 50,000 times smaller than the width of a human hair), while they can be up to several millimeters in length.
There are two main types of nanotubes: single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs)

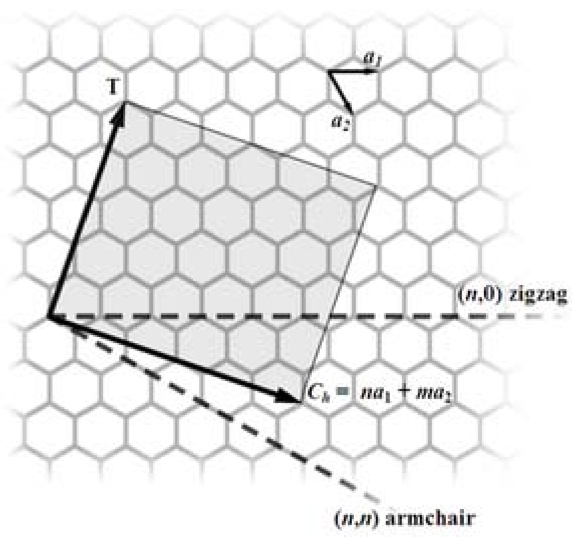

Figure 3: The (*n*,*m*) nanotube naming scheme can be thought of as a vector ($\mathbf{C}_h$) in an infinite graphene sheet that describes how to "roll up" the graphene sheet to make the nanotube. **T**denotes the tube axis, and $\mathbf{a}_1$ and $\mathbf{a}_2$ are the unit vectors of graphene in real space.

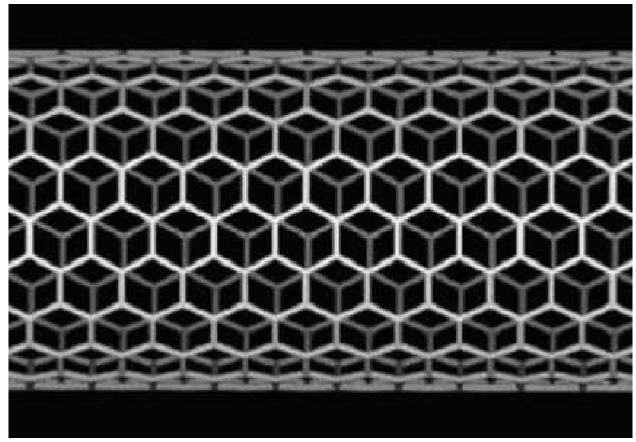

Figure 4: Computer model of a single-walled carbon nanotube

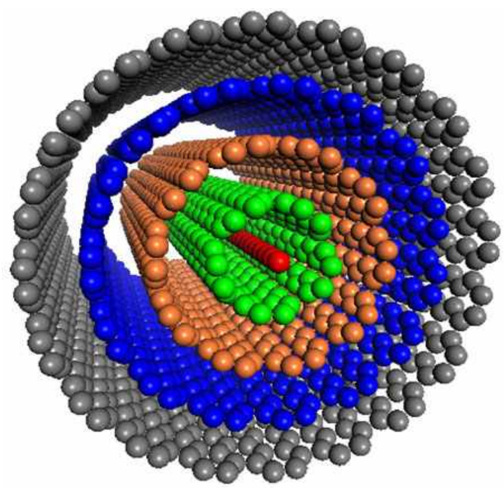

Figure 5: Multi-walled carbon nanotube

2. ACTIVATED CARBON AS ELECTRODE MATERIAL

Activated carbon is a form of carbon that is processed to make it extremely porous to have a large surface area for adsorption or chemical reaction.It is the most prevalent materials to be used in supercapacitor as an electrode.This is really cheap and source is available.

Though it is very useful but it has some limitations in different cases. Such as, Activated carbons are high surface area, high porosity carbons made of small hexagonal rings organized into grapheme sheets. Activated carbon cannot work for long range order. Activated carbon contains a wide distribution of pore sizes. surface areas for activated carbon are 1,000–3,000 m2/g. Unfortunately, a substantial fraction of this surface area resides in unpercolated pores which are inaccessible to ion migration and therefore unable to support an electrical double layer. Ions are capable of migration to some of the larger pores, though this results in an increased resistance in the electrolyte, which typically results in decreased capacitance.

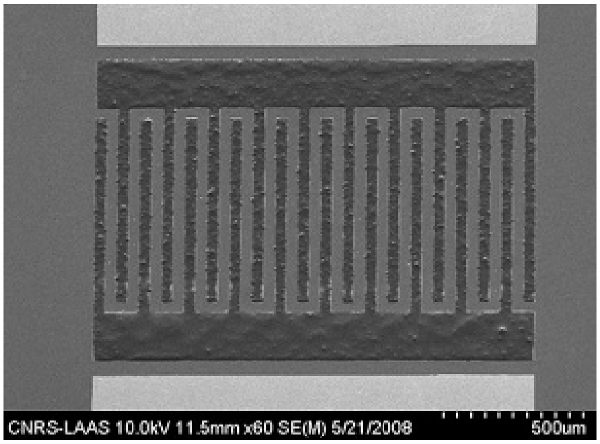

Figure 6: General view of fabricated Activated Carbon

3 CARBON NANOTUBE AS ELECTRODE MATERIAL

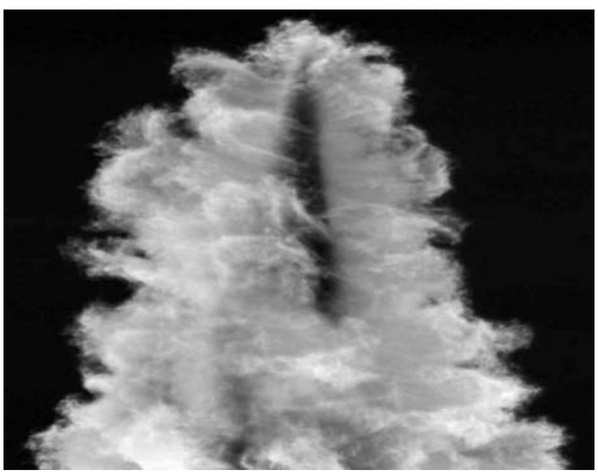

Figure 7:A Scanning electron microscope image of a metal electrode coated with carbon Nanotube

Because of some limitations of activated carbon and to increase more surface area recently scientists are developing carbon nanotube as electrode material. There are several reasons why researchers are more interested in carbon nanotube. Nanotubes have high conductivity, large surface area (1 to >2000 m2/g), good corrosion resistance, high temperature stability, percolated pore structure, and can be functionalized to optimize their properties. Perhaps the primary benefit of percolated CNT electrodes over activated carbon electrodes is the opened mesopores formed by the accessible interconnected network of nanotubes.Surface area is more accessible in carbon nanotube rather than activated carbon. CNTs are also more conductive than activated carbon. CNTs are comprised of a mix of metallic, semiconducting, and insulating materials. Some researchers have found out that acid treated nanotube electrodes can transfer electron more efficiently.This is because the band structure of CNTs are changed which is reliable for this improvement.

It is not actually developed carbon nan otube efficiently as electrode material. There is still some drawback in manufacturing. But researchers are trying hard to overcome this drawback to improve the performance. Several groups are developing different deposition strategies to enhance CNT electrode performance. For example, a recent study used a binder free MWNT electrode film fabrication method called electrostatic spray deposition. The technique showed a well-entangled and interconnected porous structure on the nanometer scale, and with the experimental setup achieved specific capacitance of 108 F/g at a scan rate of 10mV/s and a slight decrease at a 100mV/s scan rate to 103 F/g.

The difference in specific capacitances can be attributed to the altered diffusivity of the ionic species under the varying voltage scan rates. It is interesting to note that this electrode type did not require a binder for the CNT and showed good performance. The typically insulative binder acts to increase the effective resistance of the CNT electrode and decrease performance.

Functionalization and coating strategies are also being developed to optimize performance. For example, one group has shown that composite films of MWNT and ruthenium oxide (RuO2) had an energy storage density that increased about three times as compared to MWNT treated with piranha solution (a hydrofluoric acid solution).The RuO2 coated nanotubes had improved electron and ion transfer. The creation of metal centers within the CNT material should increase the energy density of the supercapacitor by providing multiple redox reactions. RuO2 notably shows great performance due to its multiple oxidation states. The excellent performance of the MWNT composites is related to the high surface area, conductivity, and electrolyte accessibility of the nanoporous structure.

Performance can also be increased via oxygenated fuctionalization and polypyrrole (PPy) coating of nanotubes.Performance of the CNT can be increased by increasing porous surface area.But the capacitance of supercapacitor can't be increased easily like CNTs because electrolyte optimization should be counted.

3. ELECTROLYTE OPTIMIZATION FOR CARBON NANOTUBE BASED SUPERCAPACITOR

An electrolyte is a solution which contains ions that behave as an electrically conductive medium. Electrolytes in chemistry commonly exist as solutions of acids, bases, or salts. The electrolyte that is used in the super capacitor can play a significant role in the power and energy densities achieved. If the electrolyte breaks down at relatively low voltages, the Super capacitor cell may not have a sufficiently high energy. several parameters can affect ionic motion: electrolyte ion size, electrolyte viscosity, surface wet ability, and electrolyte molecular weight.

The ideal EDLC has the highest surface area possible with as many ions as possible reaching the surface without being impeded. The chemical nature (bond structure, mass, reactivity, acidity, etc.) of the electrolyte is of concern for how it affects the movement of the ions through the separating membrane and to the electrode surface. To some extent there is a diffuse-layer ion distribution at the electrodes. By altering the electrolyte composition it is observed that CNT based electrode performance also altered significantly.

4. CONCLUSION

Nanotube based electrode are enhancing the performance of super capacitor which will improve the storage devices.It gives better performance than Activated carbon.Multiwalled nano tube are manufacturing and can be found in the market in a cheap rate. Yet additional researches and development is needed to make it more compatiable.

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