「정보학연구」 제10권 제2호 2007년 6월(pp.37-45)
The Journal of Information Technology, Vol.10, No.2

탄소나노튜브를 활용한 에너지 저장 소자에 관한 연구

The research regarding the energy storage device which applies the carbon nanotube

김 도 환 (Kim, Do Hwan)* · 강 순 덕 (Kang, Soon Duk)+

목 차

Abstract

The multiple-ability which the structure and the physical properties which the carbon or scull tube are unique show the applicability is superior in the plane indication element which is an indispensability of information communications apparatus, the stubbornness memory element, 2nd change of air and the rough copy dosage [khay] plaque seater, the hydrogen store material and the chemical sensor back and it has the possibility which will pass over the limit which the element of existing has. from the present paper it compared in the steel and only 10 the boat it did and it analyzed against an energy storage space voluntary application and developmental apply the carbon or scull tube trend in order about under researching the effective energy storage element it could be appeared, the technique of the strong carbon nano tube

1. The hazard which embodies the energy storage element which uses the carbon or scull tube it follows in the function which stands and CNT of the structure which is various is necessary. 2. CNT fabrications of each one must precede possible not only must be each Cabinet conference circumstances quality gain and loss. 3. The structural control of syn-

* Dept. of Computer Science and Engineering, Kongju National University
+ Dept. of Chemistry, Korea Advanced Institute of Science and Technology

theses, length controls, diameter controls and the metal - CNT junction control backs of quality CNT must precede. Applies the hereafter carbon or the scull tube in the various element with the primary preceding base technique for the structural plan technique of the carbon or scull tube to be certainly established, it does, secondarily the various element functional control technique which uses the carbon or scull tube is researched and will do.

Key words: carbon nano tube application

Ⅰ. Introduction

Nano technology is regarded as the future technology in the field of telecommunications, medicine, material science, production process, environment and energy. One of the most promising field of nano technology is carbon nano tube.

Abnormal structure and properties of carbon nano tube makes it so multi-functional that it can be applied to flat panel display, highly integrated memory element, secondary battery, supercapacitor, hydrogen reservoir, chemical sensor. It may overcome the limit of previous elements. [1]

In this paper, we studied about the energy storage element using carbon nano tube which is applied to hydrogen reservoir of mobile fuel cell or the method of catalyst. Energy storage element with carbon nano tube is light-weighted, highly conductive, stable, and large surface area that it has very good property as an electrochemically active materical.

Ⅱ. Body

1. Carbon nanotube

In 1985, Kroto and Smalley first discovered Fullerene which consists of sixty carbon atoms. Fullerene is an allotrope of carbon. In 1991, Iijima of NEC used electric discharge method and analyzed with transmission electron microscope (TEM) and found a thin and long straw-like carbon nanotube and reported in Nature. The diameter of carbon nano tube was 2.5 - 30 nm, and the length was from tens of nm to several nm. One carbon atom in a carbon nanotube is bonded to three other carbon atoms through sp^2 bonding and the diameter is only several nm that it is called nanotube.[2]

1) The structure of carbon nanotube

In carbon nanotube, graphite sheet is wrapped with diameter of nano size. It has properties of either metal or semiconductor, depending on the wrapping angle or structure. According to the number of bonding in the wall, it is classified to single wall carbon nanotube, double wall carbon nanotube, multiwall carbon nanotube.

Carbon nanotube has two different types of symmetry structures; zigzag and armchair.

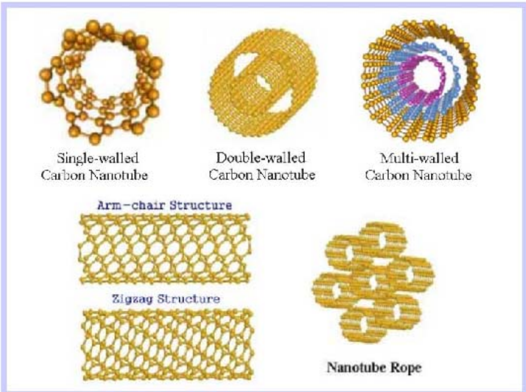

Figure 1. Carbon nanotube

However, most of carbon nanotubes have hexagonal network structures, insead of these symmetric structures. In these structures, the hexagonal structure is spirally aligned along the tube axis.[3]

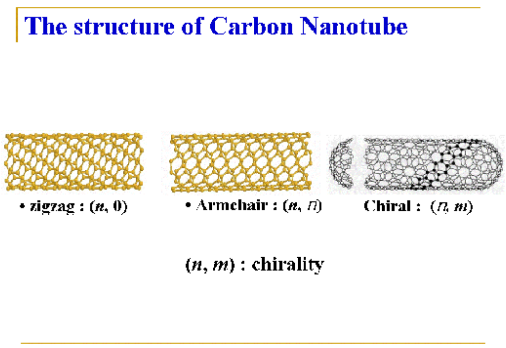

Figure 2. The structure of carbon nanotube

2. The application of carbon nanotube

1) Application as en emitter or FED

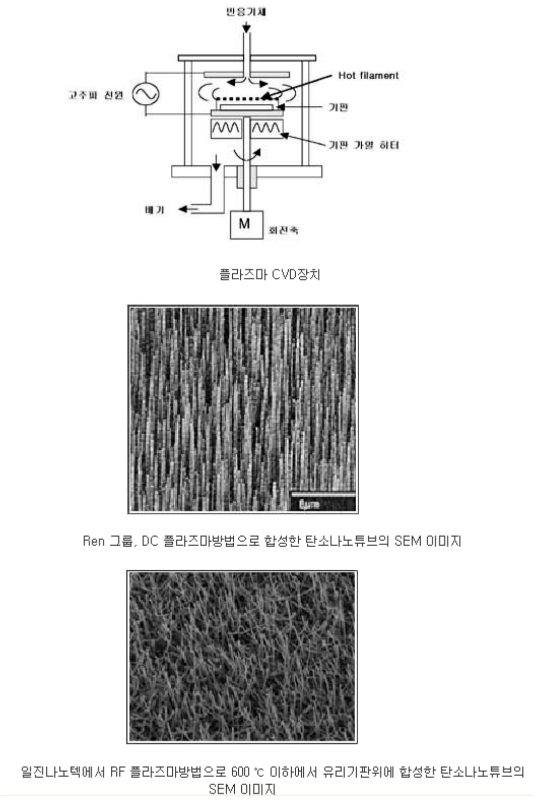

Figure 3. Scanning electron microscopy image of plasma CVD CVD

The study about the application of carbon nanotube to electron emitter and field emission display (FED) is one of the most active research items. It is predicted that flat panel displays such as LCD (liquid crystal display), LED(Light emitting diode), PDP(plasma display panel), FED(field emission display) will follow CRT(cathode ray tube) as a main display element. Among them, FED is very attractive and has the advantage of high efficiency and low power consumption. The key technology of FED is based upon the processing techniques and the stability of emitter tip and the stability. As silicone tip and molybdenum tip have serious problems in durability and stability, and have low efficiency in electron emission. Therefore, carbon nanotube is considered as a possible emitter tip with high conductivity and sharp tip. The next figure is a diagram of FED with carbon nanotube.[4]

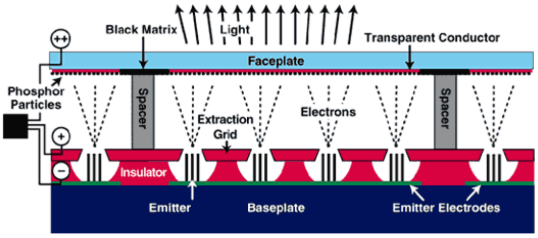

Figure 4. A schematic diagram of FED using carbon nanotube

2) Application as a secondary cell electrode and fuel cell

The application of carbon nanotube to secondary battery electrode and fuel cell has many advantageous results. The replacement of current hydrogen- adsorbed alloy with carbon nanotube can reduce the weight and increase the charging efficiency. Therefore, secondary battery electrode with carbon nanotube can be used in small mobile electronics such as car batteries, rechargeable battery, notebook computers. Fuel cell requires higher storage capacity for hydrogen. It is possible to increase the storage capacity through the use of the empty space of carbon nanotube. Carbon nanotube has light weight, and has much space to store hydrogen inside the tube. Therefore, it can store more charge per unit mass. If fuel cell with carbon nanotube is developed, it will gain attention as alternative energy source. [5]

3) The application to ultra-fine electronic switching devices

In carbon nanotube, the electric properties of metal or semiconductor can be controlled with the diameter and the type of wrapping. A tube with diameter of tens of nm can be grown. Therefore, it is predicted that a memory device with tera byte can replace current silicone devices. Dekker *et al.* from Delft university of Netherlands made nano devices of a molecular scale with SWNT at room temperature, which is shown in figure 5.

In this device, a carbon nanotube with diameter of 1 nm which has semiconductor properties connects two metal electrodes separated by 400 nm on SiO_2-deposited Si wafers. Dekker et al. found that two different types of carbon nanotubes exist and they have different current-voltage (I-V bias) behaviors upon gate voltage. First,they found metallic carbon nanotube where I-V bias is independent of gate volta and has linear property. And, they found carbon nanotube with semiconductor properties where I-V bias is nonlinear and affected by gate voltage. Fig. 22 shows a I-V bias curve of CNT-based device with semiconductor properties. The switching efficiency is about 106. With these properties, the application of carbon nanotube to FET (Field-effect transistor) will improve processor speed and miniaturization. Recently, Lim et al of Seoul national university reported that they invented carbon nanotube transistor of triod type, which is about 10 nm. This technique will reduce semiconductor device by ten thousand times. The appearance of terabit DRAM is also expected.[6]

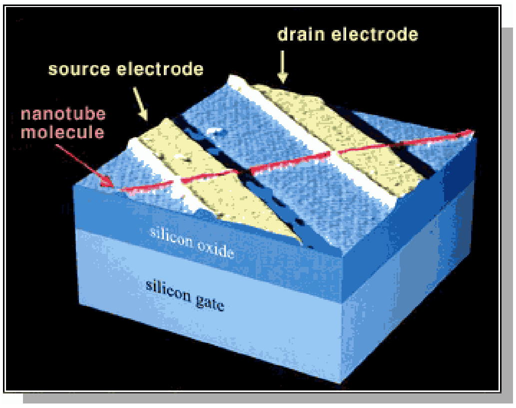

Figure 5. Nanodevice using Indivisual SWNT

3. Carbon nanotube as an energy storage device

Carbon nanotube is light-weight, highly conductive, and chemically stable. It has large surface area. These properties make CNT a good electrode active material of electrochemical energy storage device. Therefore, the use of CNT as an electrode active material of supercapacitor fuel cell and Lithium ion battery is under active research. The use of CNT as hydrogen storage device is another matter of concern.

The energy storage of supercapacitor is based upon very fast and reversible kinetic mechanism of ions, while secondary battery depends upon thermodynamic mechanism with reduction and oxidation. Therefore, the charging rate is very fast and the charge-discharge efficiency is higher and the durability of repeated charge-recharge is more than one hundred thousand times. The energy density of supercapacitor is only one-tenth of secondary battery, but the power density is almost 100 times. So it gains attention as a power supply for electric automotive.

Supercapacitors have different properties depending upon the type of CNT, electrode treatment method, and electrolyte. Sinlge wall CNT has higher specific capacitance than multi-wall CNT.

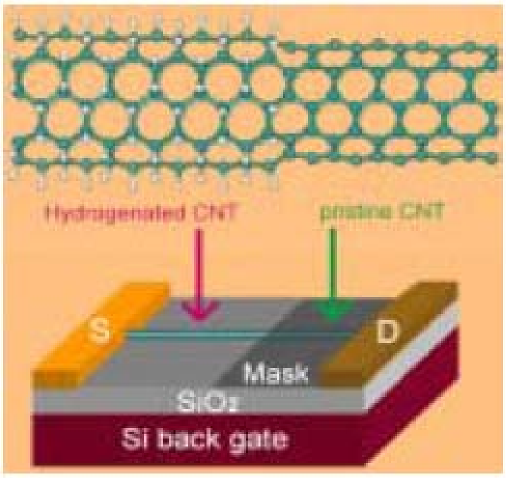

Figure 6. Schematic diagram of CNT-FET functionalized with hydrogen

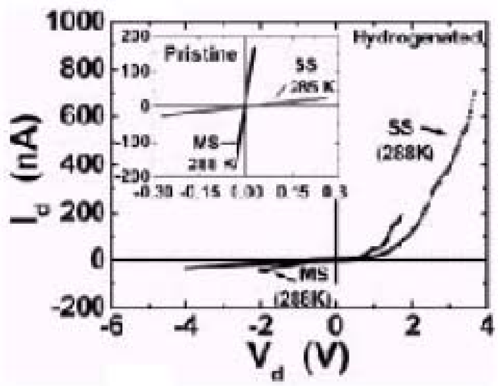

Figure 7. The change of I/V characteristic curve before and after functionalization of carbon nanotube wall with hydrogen at room termperature. Metallic nanotube changes into semiconductor nanotubes.

CNT has lower specific capacitance than graphite and active carbon which are currently used as electrode active material for supercapacitors. Meanwhile, CNT has approximate value to maximum theoretical specific capacitance with specific surface area. Therefore, specific capacitance for CNT can be improved further.

The application of CNT to fuel cell is mainly hydrogen storage for mobile fuel cell and catalyst support for reformers. The fuel cell for automobile, the largest market for fuel cell, accepts hydrogen from hydrogen reservoir or hydrogen generator inside the car. This hydrogen reacts with oxygen in air and the resulting electricity moves the car. Thus, for a higher mobile efficiency of a car, much amount of hydrogen should be made with small volume. At room temperature, hydrogen gas has 12 kg/m^3 of density at 150 atmosphere, while the reuired economic hydrogen density for fuel cell car is 63 kg/m^3 .

Thus use of automobiles with fuel cell will get practical only when a material which can store over 6.5 w% of hydrogen at room temperature using hydrogen storage device. CNT is expected to be a good hydrogen storage element, due to long nanochannel and large specific surface area which can catch hydrogen molecule. CNT with single wall is 0.7 - 3 nm wide and looks like a long pipe. It is reported that hydrogen molecule is more stable inside CNT than out of CNT. As shown in figure 8, individual CNT can function as a reservoir to store hydrogen. Theoretically proposed hydrogen storage of CNT is more than 14% of experimentally observed. Experimentally measured result is lower, but many large capacity is observed around 5 wt% as one reported in nature in 1997. According to the hydrogen storage mechanism, the hydrogen adsorption on CNT is that molecular hydrogen is physically adsorbed inside or outside of CNT. Thus the adsorption can occur repeatedly that it can be used repeatedly and permanently. It has higher adsorption and desorption rate and can be applied actually. CNT has many advantages compared with metal composite and other materials which have been studied as hydrogen adsorbent.

Another function of CNT in fuel cell is catalyst support for fuel processor. As a hydrogen source in a fuel cell, a new method to decompose methanol is under research instead of using hydrogen gas. The best catalyst to decompose methanol is platinum.

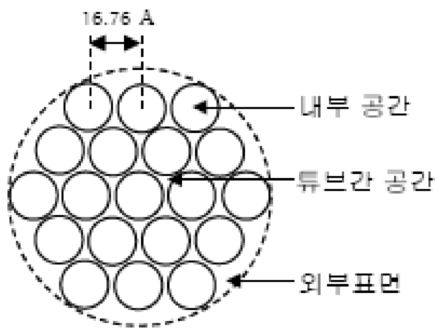

Figure 8. Hydrogen storage site in a single wall carbon nanotube.

Platinum is efficient as a catalyst, but very expensive. Thus it constitutes only half of the total fuel cell. To get maximum efficiency with platinum, platinum particles with nano size should be obtained and they should be uniformly dispersed. Carbon nanotube acts as a rigid frame to prohibit platinum catalyst from getting tangled. Amorphous network structure with carbon nanotube and broad space between CNT cause methanol to flow faster, and results in maximum catalytic efficiency. These results showed higher catalytic efficiency than other materials before.

Ⅲ. Conclusion

1. Various structures of CNT is required to give body to energy storage element with carbon nanotube.
2. It should be possible to manipulate individual CNT and each quantum properties should be understood.
3. Synthesis of high quality CNT, control of the length, control of the diamer, and junction control between metal and CNT should precede.

Primary leading technology to apply carbon nanotube to many devices includes the structural design of CNT. The study about function control of each device should follow.

References

[1] Carbon Nanotubes - Basic concepts and Physical Properties
[2] S. Reich, c.Thomsen, J. Maultzsch WILEY-VCH
[3] Lee, Young hi, Physics and high technology, pp24~30
[4] Synthesis and Application of Carbon Nanotubes
[5] High Resolution TEM Observations of Single-Walled Carbon Nanotubes
[6] Tara Spires and R. Malcolm Brown, Jr.
[7] 2nd USDC Flexible Display and Microelectronics Conference, February (2005)