A Review on the Applications of Carbon Nanotubes

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Abstract: This study describes a review of the applications of carbon nanotubes in various field. This paper consists of two main sections categorized by CNTs synthesis and properties of carbon nanotubes in field electron emission. Finally the review is concluded with several applications on carbon nanotubes focusing more in their properties. Based on study, CNT had remarkable electronic and mechanical properties that lead to unbelievable forms of power, and conductivity. The exceptional properties and characteristics of CNTs provide the potential in various applications such as electrochemical devices, nanoelectronics, composite materials, and sensors.

Keywords: Carbon nanotubes, Carbon arc-discharge, Chemical vapor deposition (CVD), Electrical Properties, Laser ablation, Electronic

1. Introduction

Carbon nanotubes (CNTs) have received much research interest as a novel material that have the wide potential for variety applications since 1991. Carbon nanotubes (CNTs) are cylindrical carbon structures with nanosized and sp^2 bonding. It has been suggested that carbon nanotubes are to be to nanoelectronics devices and other nanodevices. CNTs also have the potential for wide-ranging applications in mechanical properties, nanoelectronics, field emitters, nanodevices, conductive polymers, and as nanoprobes (Salvetat et al., 1999). CNTs can be divided into two groups, single-walled carbon nanotubes (SWCNTs) and multiwalled carbon nanotubes (MWCNTs) as illustrated in **Figure.2.** CNTs can be formed by rolling a graphene sheet (hexagonal structure) into a cylinder as shown in **Figure.1**.

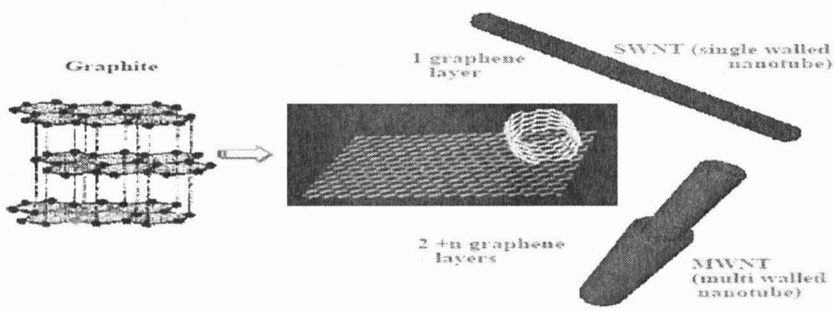
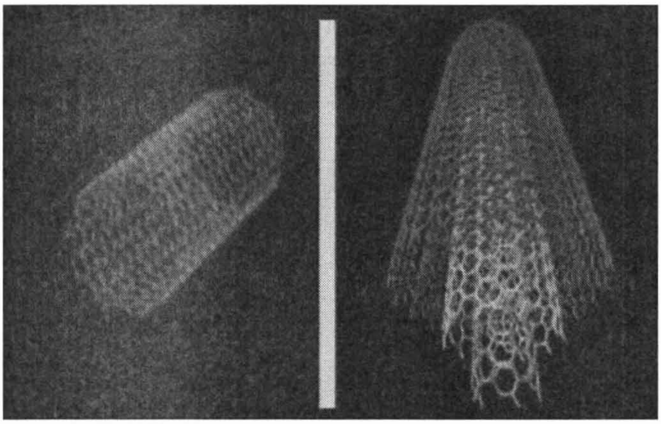


Fig. 1 CNTs can be formed by rolling a grapheme sheet (hexagonal structure) into a cylinder (Salvetat et al., 1999).



SWCNTs **MWCNTs**

Fig. 2 Schematic of an individual SWCNTs and MWCNTs (Salvetat et al., 1999).

2. Synthesis of CNTs

Three different methods are used to generate carbon nanotubes. Carbon arc-discharge, laser ablation, and chemical vapor deposition (CVD) techniques are used to synthesize CNTs. These three techniques differ in types of nanotubes, catalyst used and how much they yield. However, the CVD technique have revealed the most attraction and promising method compared to other techniques. Basically all structures of nanotubes formed in the same way but the formation is differs in the term used to synthesize them.

The first technique is already used for the formation of both SWCNTs and MWCNTs is the arc-discharge technique as shown in **Figure.3 (a)** which consists of 50% MWCNTs. MWCNTs produced by arc discharge with tubes are closed at both ends of which strike the arc between two graphite electrodes in a gas. Additions of suitable catalyst doped in anode such as Ni and Co lead to the formation of SWNT bundles. Another way to form SWCNTs is by using laser ablation as shown in **Figure.3 (b).** This method shows that the synthesis must be conducted in a horizontal flow tube with pressures under control. These methods used only 1 to 2% of metal catalyst which is evaporated using a high power laser. The flow tube is heated to 1200°C with the furnaces tube which is consisting of mixture of target such as Ni and Co. The resulting products are deposited on a water cooled copper and CNTs are formed during the cooling (Dresselhaus et al., 2000).

The most attractive and alternative method to arc discharge and laser ablation methods is the chemical vapor deposition (CVD) which is based on decomposition of a hydrocarbons gas on the transition metal with catalytic growth of carbon nanotubes as shown in Fig.3 (c) for both SWCNTs and MWCNTs. The basic mechanism in this process is the dissociation of hydrocarbon molecules catalyzed by the transition metal and saturation of carbon atoms in the nanoparticles. Carbon forms nanotubes at the surface of the catalyst film (Dresselhaus et al., 2000).

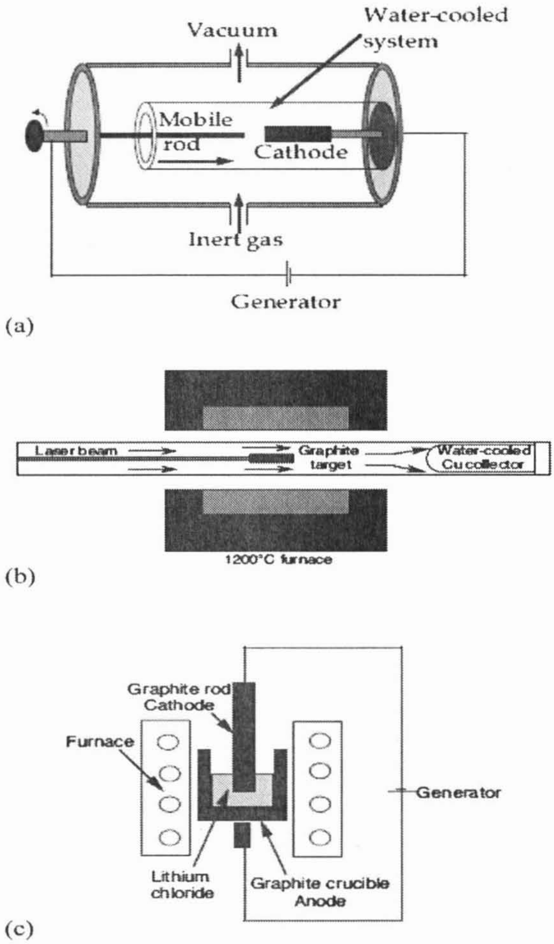


Fig. 3 Three different method were used to synthesize CNTs; (a) Carbon arc-discharge, (b) laser ablation, and (c) chemical vapor deposition (CVD) (Popov et al., 2004).

3. Properties of CNTs

CNT properties are highly dependent on their structure which is depends on how it is rolled up. Carbon nanotubes are distinctive nanostructures known to have outstanding electrical and mechanical properties. Some properties are stated below (Popov et al., 2004).

- Electrical: CNTs have extraordinary electrical conductivity and can be metallic. Their conductivity has been shown to be a function of their chirality. The electrical conductivity is high similar to Copper and with the ability to carry much current.
- Mechanical: CNTs are very flexible because of the great length with high stiffness, an absent property in graphite fibers. 100 times of the tensile strength of steel.
- Chemical: High specific surface.
- Thermal and Thermoelectric: CNTs display very high thermal conductivity. Thermal conductivity is better than the purest diamond.

4. Applications of CNTs

The most exciting aspects of carbon nanotubes are their remarkable potential for applications. Carbon nanotubes stimulate the most exciting, the unlimited promise for various applications, and now seems to have the highest commercial potential that makes them potentially useful in various applications such as nanoelectronics, composite materials, and sensors which is based on single walled carbon nanotubes (Sarrazin et al., 2005). Potential applications (Ajayan et al., 2000) have been reported such as:

- **Electronic Devices**
1. Field emission devices-displays
2. Molecular electronics-transistor
- **Energy storage**
1. Lithium batteries
2. Hydrogen storage
- **Biological**
1. Bio-sensors
2. Functional AFM tips
3. DNA sequencing
- **Composites**
- **Catalyst Support**

CNTs also can be used as SPM (scanning probe microscopic) tips because of their exceptional mechanical strength. Besides, CNTs are doubtless the best electron field-emitter and carbon nanotubes transistors (Ajayan et al., 2000). CNTs are also polymers of pure carbon and can react and manipulated using extremely rich carbon.

5. Conclusions

This paper describes a review on the applications of carbon nanotubes as well as with the synthesis of CNTs and properties CNTs. The great hint we want to express through this study is the unique nanostructures of carbon nanotubes which display the characteristics required of every other substance known. They have remarkable electronic and mechanical properties that lead to great conductivity. Because of this, CNTs provides the potential in various applications such as electrochemical devices, electronics devices, energy storage, and composites.

6. References

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