Construction of apparatus for production of carbon nanotubes (CNTs)

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Introduction

Carbon nanotubes (CNTs) are rolled up cylinders of graphene sheets [1]. There are two main types of of carbon nanotubes, namely, multi-walled carbon nanotubes (MWCNTs) and single-walled carbon nanotubes (SWCNTs) [2]. The unique nearly one dimensional structure of CNTs results in many attractive properties, which has led to many interesting applications. There are mainly three major techniques to produce CNTs. They are arc discharge, chemical vapor deposition (CCVD) and laser ablation. Though scientists are researching more economic ways to produce these structures, CNTs produced using different techniques have different properties. Due to inexpensiveness and being able to perform even in open air, arc-discharge technique has attracted attention in the production of CNT. In arc discharge, a vapor is created by an arc discharge between two carbon electrodes with or without a catalyst. Nanotubes self-assemble from the resulting carbon vapor. Both SWCNT and MWCNTs can easily be obtained by this technique simply by with or without the inclusion of a metal catalyst particle into anode. However, although arc-discharge produces large quantity of CNTs, the product is contaminated with other carbon materials, hence requiring lots of purification. Further nanotubes tend to be short with random sizes and direction when produced via arc-discharge route. In this work, we describe the development of apparatus for arc-discharge to produce CNTs using carbon electrodes made using high purity a rare variety of natural vein graphite.

Methodology

In order to produce carbon nanotubes, the first step is the construction of arc-discharging set-up. Here we describe the construction of an arc-discharge unit at UWU using home-built parts. The Instrument consists of mainly three parts. First part is the vacuum chamber. Second parts are the cathode and anode holders. Anode holder is fixed in position and the cathode holder can move up and down (or back and forth) by using a stepper motor. Another main part is the control unit. Control unit controls the steeper motor which drives the two electrodes in a controlled manner inside the vacuum. Next important step is the preparation of rod shaped graphite from > 99% pure as-received vain graphite lumps followed by purification of carbon nanotubes and characterizing those using suitable techniques such as SEM, TEM and Raman.

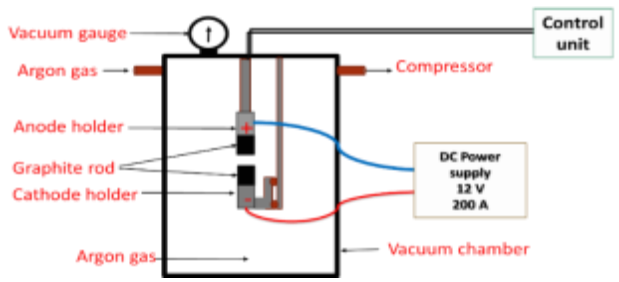

Figure 01: Sketch of the instrument

Results and Discussion

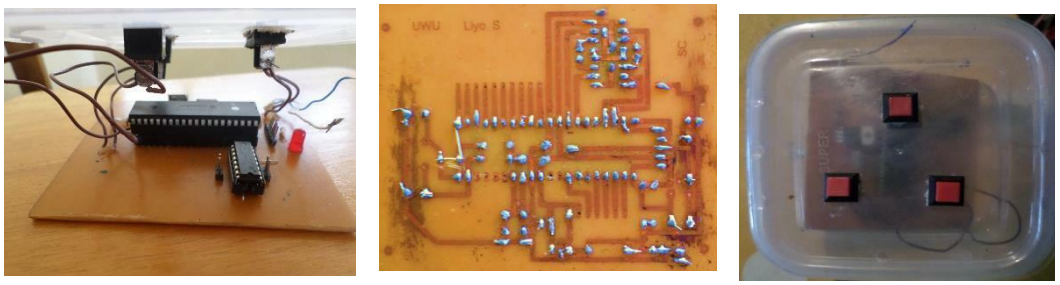

Figure 02: Control unit

Figure 03: The unit for the synthesis of carbon nanotubes

Fig. 01 shows the sketch of the apparatus. The main chamber connected to a compressor is vacuumed and filled with an inert gas. Then it is vacuumed again. This purging process with inert gas is repeated several times until air free environment is achieved inside the chamber. Then the two carbon electrodes are connected to the power supply and move slowly towards each other using a remote control unit until arc-discharge starts to appear. Then the two electrodes are held at this position for a while (30 seconds or so) and are moved very slowly backward to collect CNTs produced on cathode as a result of the evaporation of the anode. Figure 02 display the main parts of the control unit which was designed and developed at UWU. Fig. 3 shows the vacuum chamber discharge unit which was also constructed completely at UWU using home-built device components. . One of the major tasks in the development of the vacuum chamber was to find an effective way of sealing it enabling to maintain an inert condition in the chamber. Finding an effective sealant was not a trivial task. However this was elegantly overcome by using a combination then how to make the graphite rods from graphite lumps. The working condition of the setup is, 200A direct current and 20 V potential given between anode and cathode in an inert atmosphere. Ar, He and N_2 can be used as inert environment. Because He is a good heat conductor, it is used widely in arc-discharge systems. On the arching position, the anode graphite rod evaporated due to the high temperature and deposit on the cathode rod as the rod shaped mixture of carbon nanotubes. In this mixture there are so many impurities like amorphous carbon, metal particle and Bucky balls. Before characteristics of carbon nanotubes, we have to remove the impurities. The system is currently in working conditions and by this Instrument can obtain high quality and straight multi-walled carbon nanotubes.

Conclusions

An arc discharge system capable of producing CNTs was successfully constructed. The instrument is working properly. From this instrument, without using a catalyst, it is possible to obtain multi-walled carbon nanotubes.

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