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The Effect of Sputtering Current and Carbon Layer Thickness on the C-V Characteristics of Si-CNT

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Abstract: In the preparation of Si-CNT (Silicon – Carbon Nano Tubes) without a catalyst, the plasma Sputtering Techniques were used to prepare Nano diodes for use in Nano-electronic applications. For the Si-CNT junction, the effect of current and carbon layer sputtering on the C-V properties has been studied. Carbon layers were rendered on silicon wafers by the plasma sputtering in the Argon gaseous atmosphere with various thicknesses and deposition currents without catalysts by deposition of pure graphite rod carbon. There were two methods used to prove CNT and study its structural properties, Raman spectroscopy and Scanning electron microscope (SEM), the two methods were used. C-V Characteristics indicate that: increasing CNT thickness increases the potential of the same sputtering current by increasing the length and diameter of the carbon nanotube and interacting with them which contributes to grain mixing and mixing. Growing the sputtering current has no impact on the low thickness layer due to lower sensitivity to sputtering plasma, however it affects thick layers as SEM and AFM images demonstrate.

Keywords: Carbon Nano tubes, Si-wafer, Si-junction, plasma sputtering and C-V characteristics.

1 Introduction

Carbon nanotubes have obtained great results with their esteemed properties in all fields of science and technology and have been increasingly one of the key parts of advanced technology [1,2]. Nano diodes are a vital component of electronic nanotechnology for the urgent processing of Nano processors, communications microprocessors, network science, robotics, nanotechnology, etc. [3].

The electric and electronic characteristics of CNT diodes are one of the most promising properties for newly Nano devices in all fields of science and technology, and C -V characteristics are of interest for understanding factors that influence the characteristics of CNT diodes [4]. So great is the effect of method of preparation and on the properties of the CNT tubes and especially on electrical and electronic properties of CNT diodes [5]. Different methods are used to prepare carbon nanotubes such as chemical vapor deposition (CVD) [6], chemical bath deposition CBD, arc discharge and plasma sputtering [7]. All of these methods were based on the deposition of carbon using catalyst [8,9], such as iron and cobalt for the construction of carbon nanotubes while, different in the working mechanism and the preparation temperatures [10,11]. One of the main processes is the plasma sputtering [12]. Which is easy to handle, permits good control on the growth, also low contamination, and homogenous samples [13], as we found during our long treatment with this method [14].

Several techniques have been used to detect the existence of carbon nanotubes, including the Raman spectra, the G and d bands proves the existence of CNT [15]. the scanning electron microscope SEM Are great tools to study the structural aspects of the CNT [16]. These techniques were used to classify carbon nanotubes into two types, SWCNT and MWCNT and each type possessing different physical and chemical characteristics [1- 3].

We used plasma sputtering techniques in this research to prepare Si-CNT without catalyst. Also relevant is the capacitance value for the correct diode activity and a need for analysis of the effect on the C -V characteristics of Si-CNT relation of sputtering current and carbon layer thickness. The existence of Nano carbon tubes and its structural features must be assured by different methods: Raman spectroscopy, electron microscopic scanning and atomic force microscopy.

2 Experimental Methods

For the development of nanotubes without catalyst, the sputtering process was used for plasma. Carbon and

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reactive gasses (Argon) are inserted into the chamber by a set of mass flow controls to monitor the mixture's flow rate and gas composition. An ionized gas is generated by a high voltage applied to the electrode above the sample, resulting in the release of plasma. The regulation of growth parameters will affect growth rate and diameter by this approach. Silicon wafers were used to prepare the Si-CNT interconnection layer for the nanotube. For square parts (1x1 cm^2) of estimated surface, a glass cutter was used to create a silicon wafer, Weather [4]. An extremely pure carbon graphite tube was made for the manufacture of the SI-CNT crossover by means of a helium-sputtering process, with a precipitate current of 70, 80 and 90 A Pulses, in a plasma Nano-tubes of a variable thickness.

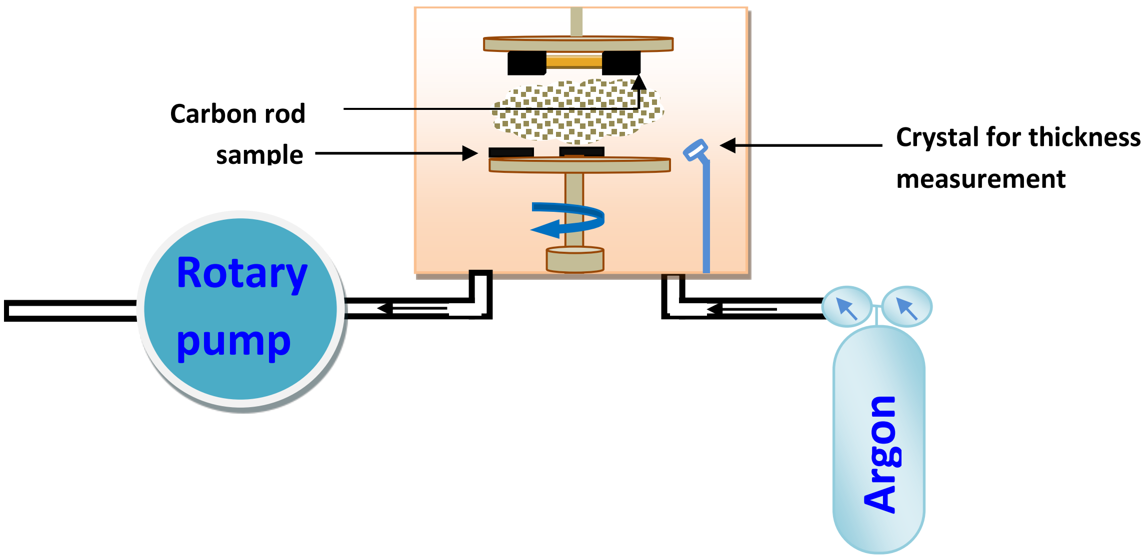

Fig. 1: Schematic diagram of plasma sputtering unit.

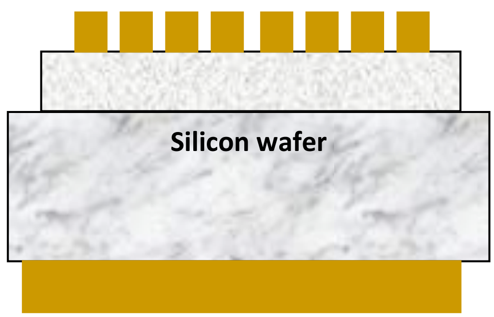

Fig. 2: The Si-CNT junction the upper and lower layers with Gold contacts.

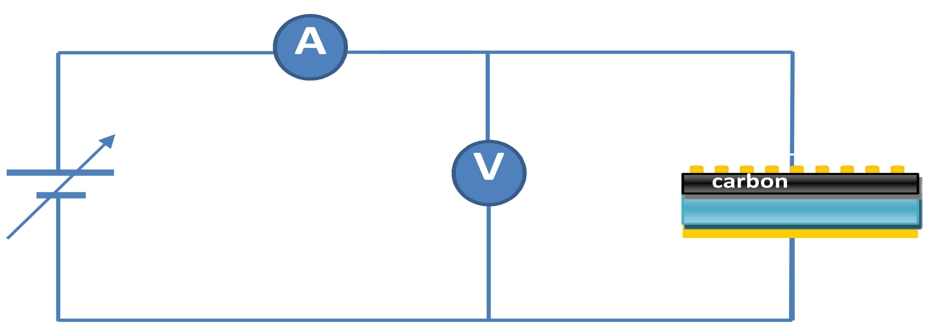

Fig. 3: The electrical circuit used to measure the I-V characteristics, with different thicknesses and with different preparation currents.

Figure (2) shows the Si-CNT junction the upper and lower layers are Gold contacts, the lower part of the junction is the back Gold contact, the layer above the silicon wafer, is Nano the tubes carbon layer.

After preparation of the samples with different thicknesses of the CNT layer, each sample was connected to circuit shown in figure (2) to measure the C-V Characteristics. Figure (3) The electrical circuit used to measure the C-V characteristics, with different thicknesses and currents, to study Their effects on C -V. Raman spectroscopy was used to prove existence of CNT and to study its structural characteristics as in figure (3). Several time the measurements repeated to assure accuracy.

3 Results and Discussions

Raman spectroscopy was used to prove existence of CNT and to study its structural characteristics as in figure 4.

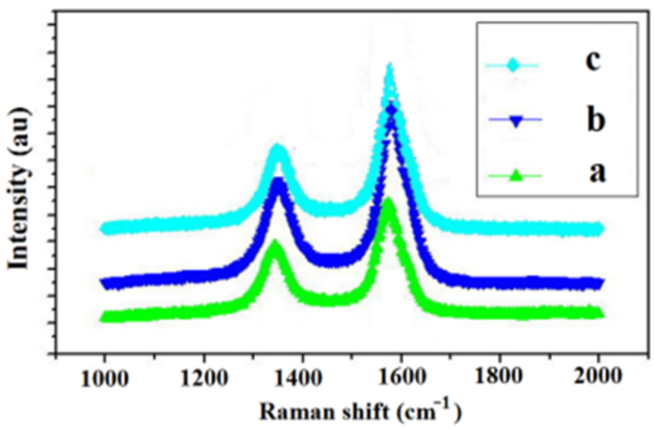

Fig. 4: Raman spectrum of C layers with thicknesses (a-20, b-40 and c- 60 nm) and 70 A sputtering current, the D band 1357 and G 1588 cm^{-1} proves the existence of CNT [8].

In figure (4), Raman spectrum of Carbon layers with thicknesses (a-20, b-40 and c- 60 nm) using 70 A sputtering current and different time periods, is shown which give clear evidence of formation of the CNT tubes because the appearance of the D band 1357 cm-1 and G 1588 cm-1 proves the existence of CNT [15]. Also studied different SEM images of the Nano carbon layers which was deposited on silicon wafer using different puttering and for different thicknesses to see the effect of the above two factors (thickness of CNT layer, sputtering current) on the structural properties of this Layer and as a result to explain the effect of these factors on figure (5) shows Scanning electron microscope images of Carbon layers for sputtering currents (90, 80 ,70 A for the rows upper, intermediate and lower three figures) and for different thicknesses (20,40 and 60 nm for the three columns in figure as a, b, c). The image clearly shows two factors (thickness of CNT, Sputtering current) on the structure of the CNT.

Figure (5) shows Scanning electron microscope images of Carbon layers for sputtering currents (90, 80 ,70 A for the rows upper, intermediate and lower three figures) and for different thicknesses (20,40 and 60 nm for the three columns in figure as a, b and c)

Insight study of the nine figures above shows that increasing the Sputtering current have great effect on the structure of the thicker CNT layer, conversely low thickness CNT layer show little effect on the structure of CNT layer. Insight study of the samples shows clear evidence of increase of diameter of Nano tubes of the CNT layer with increasing thickness of the CNT layer for all values of sputtering current, because more carbon layers are added to the Nano tubes, which increases the multiwall Nano tubes diameter and length [6].

C-V characteristics shows that for all three figures with different values of the sputtering currents increase of voltage increases capacity for all thicknesses will increase the capacitance. But for the same voltage there are increase of capacitance with increase of carbon Nano tube thickness.

In addition to the formation of grains with in the layer, also we realized that the increase the sputtering current will prevent the growth of grains within the carbon layer Which increases the level of layer purity as a result of continuous etching of the carbon layer by the plasma during the deposition process which is in agreement with the published researches [17].

Increasing sputtering current have little effects on the low thickness CNT layer and shows stable I-V characteristics. This behavior is not the same for high and intermediate thickness CNT which shows that: Increasing sputtering current have big effects on the high and intermediate thickness CNT layer and shows unstable but systematic change in the I-V characteristics and shows plateau at high .This capacitance increase with increasing carbon layer thickness this can be due to formation of grains due to interference of Nano tubes due to increase of their diameters and lengths .this effect is absent in low thickness and low diameter CNT. Also the increase of capacitance shows uniform increase with increase of thickness for intermediate and high thickness by increasing sputtering current.

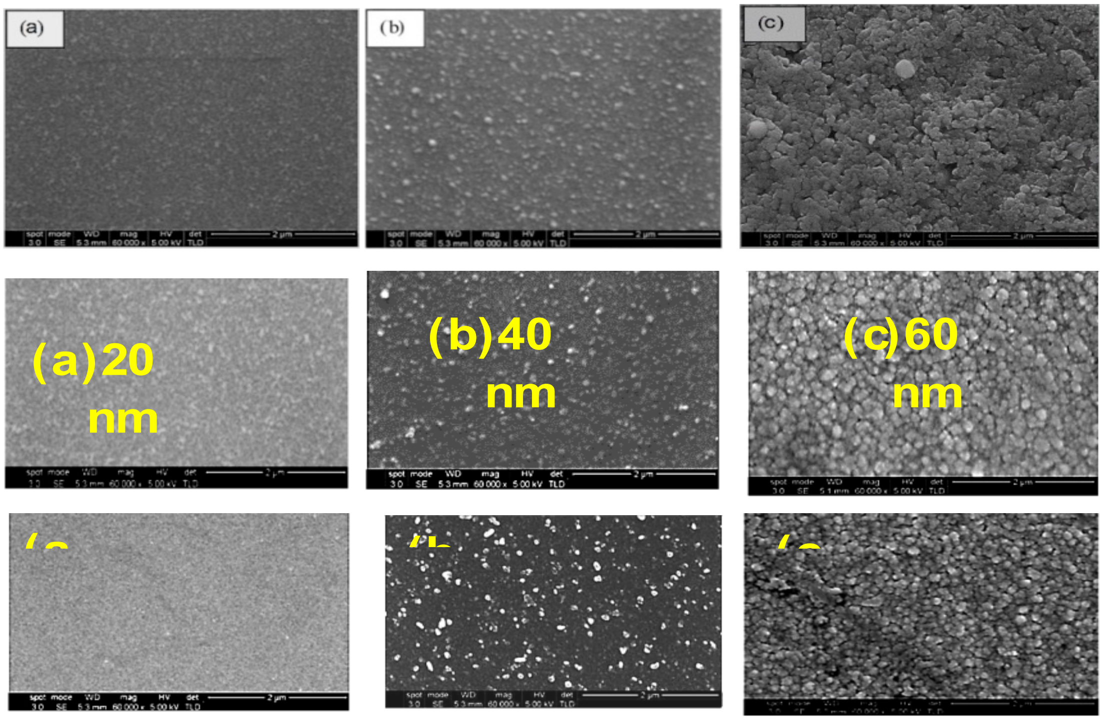

Fig. 5: shows Scanning electron microscope images of Carbon layers for sputtering currents (90, 80 ,70 A for the rows upper, intermediate and lower three figures) and for different thicknesses (20,40 and 60 nm for the three columns in figure as a, b and c).

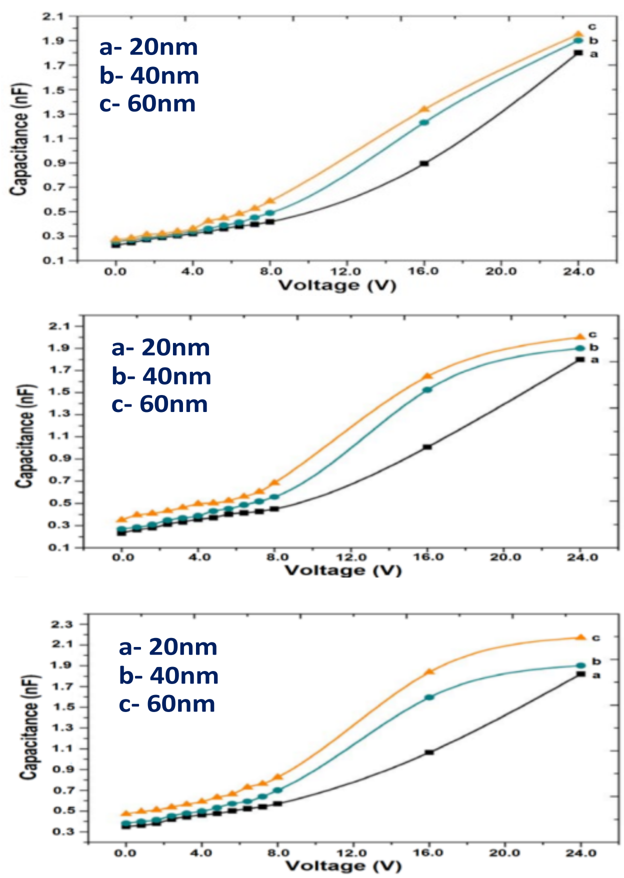

Fig. 6: The I-V measurements with sputtering currents from above to lower figures, for 70 A, 80A and 90A.

4 Conclusions

The growing sputtering current has no influence on the low-thickness CNT sheet. The C-V properties are stable. Growing sputtering current has significant consequences on the high and intermediate CNT thickness sheet. The C-V characteristic shifts are unpredictable and systematical, and the plateau is present in the high field. This may be due to grain forming due to intrusion by Nano tubes due to the increasing diameter and length, this effect is absent at low thickness and medium-diameter CNT. The potential increases with increased thickness of the carbon substrate. The increase in capability indicates a standardized increase by the increased sputtering current, by medium and high thickness.

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