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A Systematic Study of Electronic Properties of a Single Walled Bent Carbon Nano Tubes

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Abstract—The present paper reports the systematic study of electronic properties of single walled bent carbon nanotube. Bent carbon nanotube can be considered by as a graphitic one atom thick be rolled into a cylindrical tube whose radius be less than 1nm and diameter be 1.4nm[1].Carbon nanotube is discovered in 1991.The remarkable electronic properties of these structure have attracted much attention. The usual approach to the theoretical modeling of buckling phenomena has so far made use of classical potential .Even for calculation of the electric properties of bent carbon nanotube, which make use of relative more sophisticated quantum tight binding Hamiltonian, the scattering geometry of bent carbon nanotube has been obtained using classical potential[2].Nanotechnology is a technology uses the bent carbon nanotube as a nano material for fabrication of many kinds of nano devices and their nano structures[3].The arrangement of graphitic rings in the walls of carbon nanotube indicates that the carbon nanotube be metallic or semiconducting[4-8]. Here scanning tunneling microscopy[STM] provides the necessary potential to probe this prediction, and it can be resolved simultaneously both atomic structure and electronic density of states(DOS).Previous STM studies of multiwall nanotube and single walled nanotube have provided indication of different structures and diameters depending on electronic properties, but have no any explicit relation between structure and electronic properties of carbon nanotube[9-13].Here we report STM measurements of the atomic structure and electronic properties of single walled carbon nanotube(SWCNTs).Here we are able to resolve the hexagonal ring structure of the walls of CNT and show that the electronic properties depend on diameter and helicity. Finally we conclude that the SWCNT samples exhibits many different structure with no one species dominating. After that we can write conclusions of our work.

Key words: Carbon nanotubes, nanotechnology, scanning tunneling microscopy, electronic properties.

1. INTRODUCTION

Nanotechnology-Nanotechnology is a field of applied science and technology covering a broad range of topics. The main unifying theme is control of matter on a scale smaller than micrometer as well as the fabrication of devices on this same scale. It is a highly multidisciplinary field, drawing from same field, such as colloidal science, device physics and super molecular chemistry. Much speculation exists as to what new science and technology might result from these lines of research[14]. Nanotechnology and nanoscience got started in the early 1980s with two major developments: The birth of cluster science and invention of STM. This development led to discovery of fullerenes in 1985 and carbon nanotube have recent received extensive attention due to their nanoscale dimension and outstanding materials properties such as ballistic electronic conduction, immunity and electro migration effect at high current densities and transparent conduction[15].

Carbon nanotube-When a grapheme sheet of one atom thick can be rolled into a tube then obtained helical tube is called carbon nanotube. Bending of nanotube provides buckling and this buckling is usual way for nanotube to reduce its strain. After that relaxed configuration is obtained. Here we consider only individual single walled carbon nanotube for our research work[16]. Fabrication of nanotube is demonstrated in fig.1.

Scanning Tunneling Microscope(STM):-Scanning Tunneling Microscope(STM) is a device that obtains images of the atoms on the surface of materials. The STM is not an optical microscope, instead, it works by detecting electrical forces with a probe that tapers down to a point only a single atom across. The probe in the STM sweeps across the surface of which an image is to be obtained. The electron shells or clouds, surrounding the atoms on the surface produced irregularities that is detected by the probe and mapped by a computer into an image. The resolution of image is on the order of one nanometer(1nm)or less where 1nm=0.000000001meter=10^{-9}m[17].

Steps for taking in research work-

(1) Fabricate single walled carbon nanotube. (2)Take STM measurement of these tube in ultra high vacuum environment(3)Observe their metallic and semiconducting nature. (4)We take observations and conclusion.

After that we find and reach on the conclusion that STM characterisation combined with growth and purification, a rational path way for producing structural homogeneous samples of nanotube in the future applications.

2. RESULTS AND DISCUSSION

Metallic and semiconducting nature of nanotube-Here we use a vector equation, $c_{h=}na_1+na_2$ =(n, m), where a_1 and a_2 are graphite lattice vectors and n and m are integers as demonstrated in fig.2. By use of this equation we can characterise the diameter and helicity of defect free SWCNTs. Indices (n, m) describes the metallic or semiconducting behaviour of SWCNTs. Zig-zag(n, o)SWCNTs having two distinct type of behaviour. If n/3 is an integer then the tube will from (n, o), chiral(n, m) SWCNTs are possible with electronics properties similar to zig-zag tubes, that is, when (2n+m)/3 is an integer then the tube are metallic and otherwise semiconducting. The gaps of semiconducting(n, o) and (n, m) tubes should depend on diameter . In finally when c_h rotates by 30^0 relative to(n, m), n=m. Then the (n, m) armchair tubes are expected to be surely metallic with band gap, crossing at k=2/3 of the one dimensional Brillion zone. Since the SWCNTs samples produced by laser vaporisation and arc[18, 19] methods consisting predominantly of (10, 10) metallic arm chair tubes.

STM measurements in ultra high vacuum environment;-For our work we use STM measurement in ultra high vacuum at 80k and IT Isolated SWCNTs on Au(111) substrate are demonstrated in fig.3 and 4 respectively . It identifying the zig-zag tube axis direction, then chiral angle is determined. This process shows quite clearly that the $+8.0\pm0.5^0$, with respect to zig zag nanotube. In fig. 2, the tube axis is perpendicular to c_h which corresponds to the angle between c_h and (n, o).The measured diameter of 1.0±0.05nm now we can assign (n, m) that indices either (11, 2) or (12, 2), the angle/diameter for (11, 2) and (12, 2) are -8.2^0/0.95 nm and -7.6^0/1.03 nm respectively. We find that (11, 2) tube is expected to be metallic. whereas (12, 2) tube should be semiconducting. As chiral angle be -11.0±0.5 then the helicity of lower isolated single walled nanotube(SWCNTs) IN FIG.4 IS determined, the diameter of this tube is 1.08±0.05nm. These parameters match closely the values expected for a (12, 3)tube $+10.9^0$/1.08nm.Our main motto to characterize the electronic properties of this atomically resolved carbon nanotube by tunneling spectroscopy, mainly current(I) versus voltage(V) measured at specific sites along the tubes and we differentiated to yield the normalized conductance, (V/I)/(dI/dV). This shows to provide good measurement of the main features in local density of electronic states for metals and semiconductors[20]. The continuous increase in current in I-V data (fig.5 and 6), recorded on the SWCNT, shows(imaged in fig.3 and 4) qualitatively the both tubes are metallic. These spectroscopic results are similar to those obtained on the Au(111) substrate.

The metallic behavior of our (12, 3) tube is in agreement with prediction that (2n+m)/3 is an integer and additionally suggests that the indices for the tube in fig.3 are (11, 2) rather than (12, 2).We have also discuss a metallic, a chiral, zig zag SWCNT with a diameter of, 0.95±0.05nm. This diameter is very closer to 0.94nm diameter of a(12, 0)tube

The first curvature in the SWCNTs of grapheme sheet causes the pie by sigma, bonding and pie star by sigma star ant bonding orbital's on metallic tube[6, 8]. The second curve(fig.6), the LDOS recorded on metallic SWCNTs in a rope and isolated on the substrate are similar, hence we suggesting that inter tube interactions do not perturb the electronic structure on the energy scale of 80k.

Analysis of image of fig.7, shows that the upper tube has a chiral angle of 11.2 ± 0.5^0nm and diameter of 0.95±0.05nm.These angle /diameter, constraints agree best with the 11.7^0/1, 0 nm for a(14, -3) indices are close to our uncertainty.

The I-V data recorded with atomic resolution image is tube and is consistent with semiconductor that is the current is very small. The observed semiconducting behavior is consistent with the explanation that a (14, -3) tube should be a moderate gap semiconductor. A summary of energy gaps(E_g) obtained from these measurements for tubes with diameter between 0.6 and 1.1nm is demonstrated in fig.9. These results show that the expected diameter, can be fitted to $E_{g=}$2time of gamma and a_{c-c}/d, where the value of gamma is equal to 2.45Ev. This value of gamma is very near to 2.5eV that is determined from calculations.

3. OBSERVATIONS AND CONCLUSION

We find that in our observations of semiconducting and metallic single walled carbon nanotube with some change in structure. Clearly confirm the remarkable electronic behavior of nanotube. We sure that these results having very high significant applications for present and in future .First data shows the richness of structure and indicate that no one SWCNT type dominates. This observation contrasts with previous suggestions that SWCNT prepared by laser vaporization method consists primarily of (10, 10) armchair tubes. Such results could help to elucidate the growth mechanism. The presence of large fraction of semiconducting nanotube should be considered when interpretating electrical measurements that probe the bulk properties of rope that is temperature, dependence resistivity and doping and induced charge in electrical conductivity [21]. We believe that STM characterisation combined with growth and purification studies will provide a rational path way for producing structurally homogeneous samples of nanotubes in the future applications.

4. FIGURES

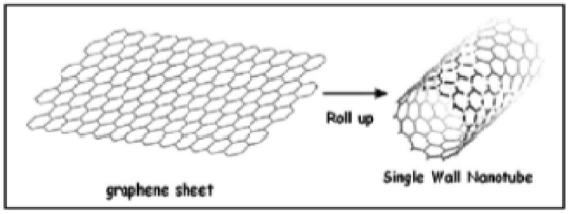

Fig 1

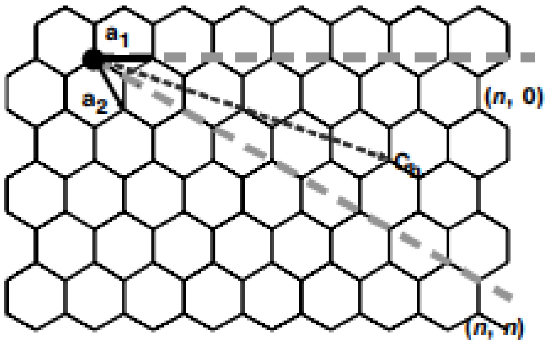

Fig. 2

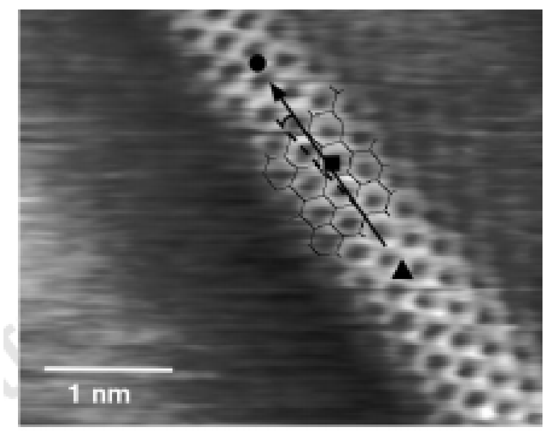

Fig. 3

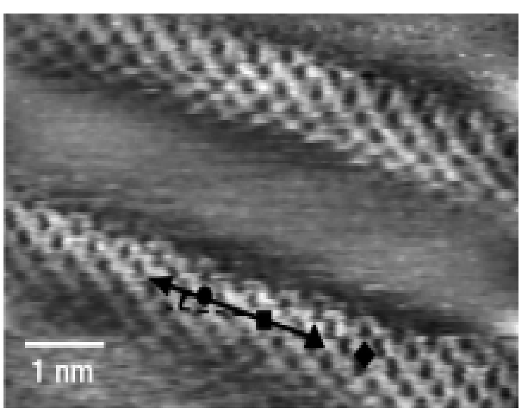

Fig. 4

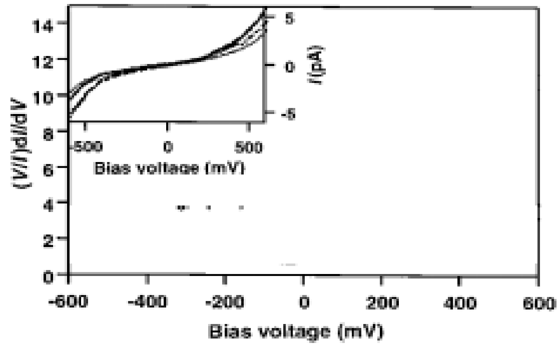

Fig. 5

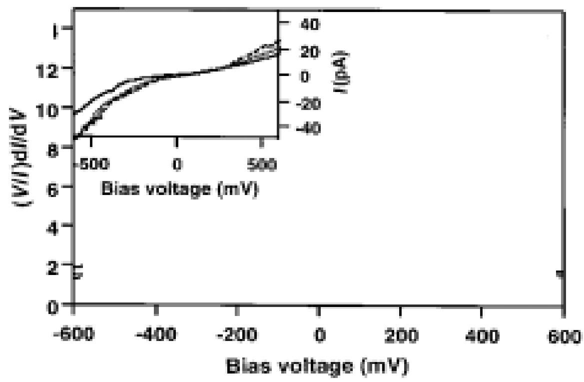

Fig. 6

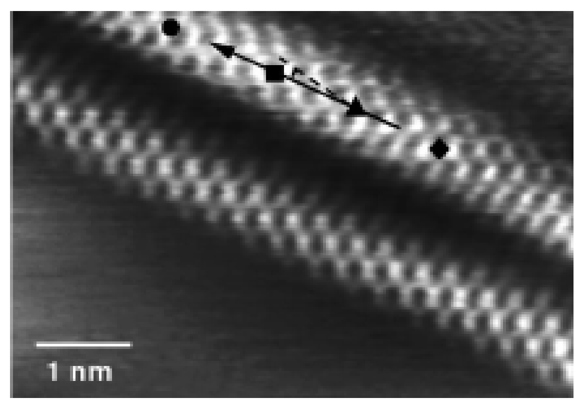

Fig. 7

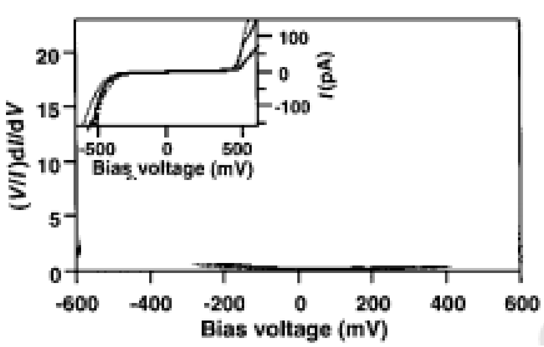

Fig. 8

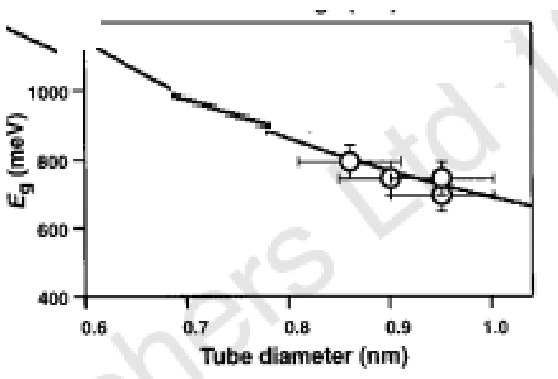

Fig. 9

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