Applications of Carbon Nanotubs and Other Nanomagnetic Nanowires

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Abstract— Ultra high data storage media need smaller spacing between head and media. Signal processing and noise problems should be included in the development of a road map of ultra high data storage systems. The fast development in magnetic recording media give the consumer and users of computer systems more hope to gain power on their systems. The magnetic recording media industry will benefit strongly from the advances in magnetic nanostructures (based on carbon or other materials). The production of ultra-high recording media with advanced lithography is possible and practical. That is why, nano-magnetic structures could be one of the best candidates for new recording technology concepts.

1. INTRODUCTION

Since their discovery, carbon nanotubes have attracted the attention of many scientist around the world [1]. In 1991, S. Iijima discovered Carbon Nanotubes by chance during investigation of fullerene production. Since then, Carbon Nanotubes have attracted the immense interest among the researchers and has been the focus of many research projects [2]. The functionalisation of carbon nanomaterials can modify their physicochemical properties, making them more suitable for chemical and biological applications. Of particular interest are CNTs with magnetic properties because of their potential applications in biological labelling, drug delivery and magnetic storage media [3]. Electrical properties of carbon nanotube structures and manifestations in related phenomena such as thermoelectricity, superconductivity, electroluminescence, and photoconductivity are important fields of research. The possibility of using naturally formed complex nanotube morphologies, such as junctions, for new device architectures are then considered. Technological applications of the electrical properties of nanotube derived structures in transistor applications, high frequency nanoelectronics, field emission, and biological sensing are also other fields of study. The technological potential of nanotubes and the need for new device architectures for nanotube systems integration has been review [4]. A widely used approach to identify the types of SWCNT is by reference to rolling up the graphene sheet. The key geometric parameter associated with this process is the roll-up vector r, which can be expressed as the linear combination of the lattice basis (a and b) [5].

$$r = na + mb \tag{1}$$

Carbon nanotubes can be visualized as a graphene sheet that has been rolled into a tube with hemispherical caps at both ends [6]. Unlike diamond, where a 3-D diamond cubic crystal structure is formed with each carbon atom having four nearest neighbours arranged in a tetrahedron, graphite is formed as a 2-D sheet of carbon atoms arranged in hexagonal array. In this case, each carbon atom is linked to three nearest neighbours. Rolling the sheets of graphite into cylinders form carbon nanotubes. The properties of nanotubes depend on atomic arrangement (how the sheets of graphite are rolled), the diameter and length of the tubes.

It is then possible to associate a particular integer pair (n, m) with each SWCNT. The relation between n and m also defines three categories of CNT: $m = 0$, Zigzag, $n = m$, Armchair, other, Chiral.

Regarding electrical conduction, carbon nanotubes show the unique property that the conductivity can be either metallic or semiconducting, depending on the tubule diameter d, and chiral angle [7, 8]. It is theo-retically predicted that 1/3 of as prepared CNTs are me-tallic and 2/3 are semiconducting. Moreover, the band gap of the nanotube is tuned by adjusting the diameter of the nanotube. Hence electronic structure of a CNT de-pends only on its geometrical dimension without any doping [8].

2. CNT POSSIBLE APPLICATION

Among the organic materials, carbon Nanotubes (CNTs) are unique for their electrical and chemical properties. They are very interesting in terms of material research and electronic applications.

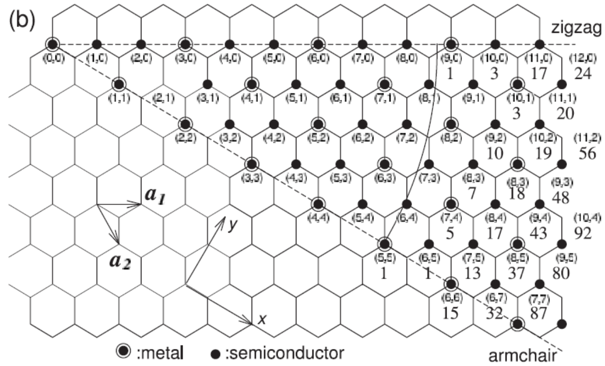
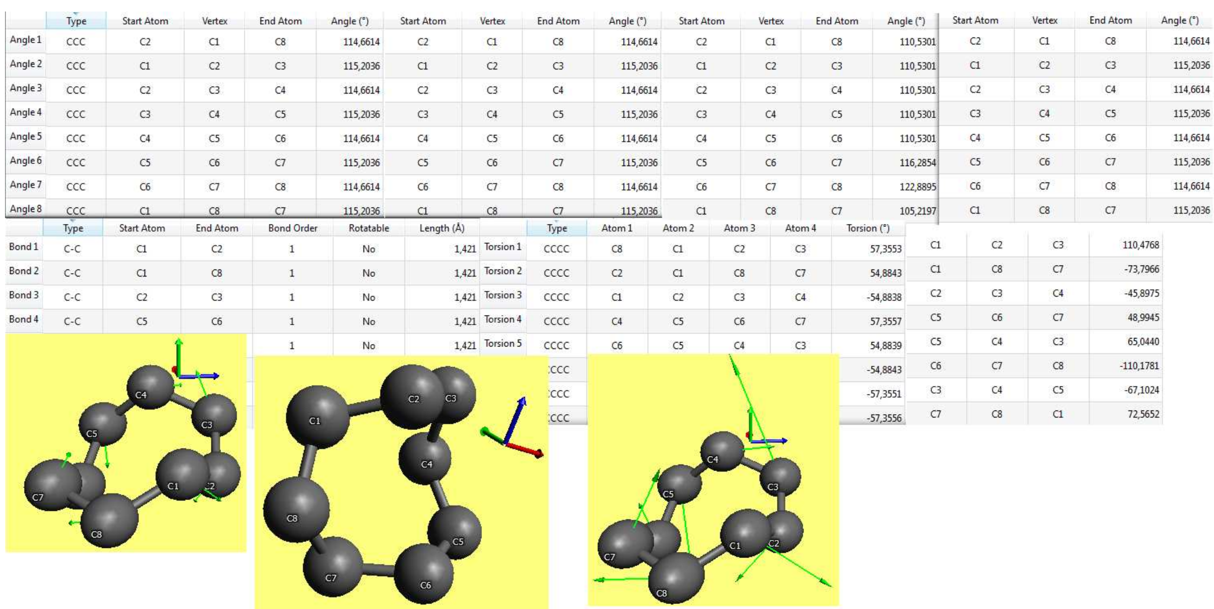


Figure 1: Possible vectors specified by the pairs of integers (n, m) for general carbon nanotubes, including zigzag, armchair, and chiral nanotubes [7].

Depending on their chemical structure, carbon nanotubes (CNTs) can be used as an alternative to organic or inorganic semiconductors as well as conductors. The chemical bonding of nanotubes is composed entirely of sp^2 bonds, similar to those of graphite. This bonding structure, which is stronger than the sp^3 bonds found in diamonds, provides the molecules with their unique strength. Nanotubes naturally align themselves into "ropes" held together by van der Waals forces. The nature of the bonding of a nanotube is described by quantum chemistry specifically, orbital hybridization. Solvents in which the CNTs can be solubilized include chlorobenzene, chloroform, methylene chloride, carbon disul.de, benzene, etc. [9].



	Type	Start Atom	Vertex	End Atom	Angle (°)	Start Atom	Vertex	End Atom	Angle (°)	Start Atom	Vertex	End Atom	Angle (°)	Start Atom	Vertex	End Atom	Angle (°)
Angle 1	CCC	C2	C1	C8	114,6614	C2	C1	C8	114,6614	C2	C1	C8	110,5301	C2	C1	C8	114,6614
Angle 2	CCC	C1	C2	C3	115,2036	C1	C2	C3	115,2036	C1	C2	C3	110,5301	C1	C2	C3	115,2036
Angle 3	CCC	C2	C3	C4	114,6614	C2	C3	C4	114,6614	C2	C3	C4	110,5301	C2	C3	C4	114,6614
Angle 4	CCC	C3	C4	C5	115,2036	C3	C4	C5	115,2036	C3	C4	C5	110,5301	C3	C4	C5	115,2036
Angle 5	CCC	C4	C5	C6	114,6614	C4	C5	C6	114,6614	C4	C5	C6	110,5301	C4	C5	C6	114,6614
Angle 6	CCC	C5	C6	C7	115,2036	C5	C6	C7	115,2036	C5	C6	C7	116,2854	C5	C6	C7	115,2036
Angle 7	CCC	C6	C7	C8	114,6614	C6	C7	C8	114,6614	C6	C7	C8	122,8895	C6	C7	C8	114,6614
Angle 8	CCC	C1	C8	C7	115,2036	C1	C8	C7	115,2036	C1	C8	C7	105,2197	C1	C8	C7	115,2036

	Type	Start Atom	End Atom	Bond Order	Rotatable	Length (Å)
Bond 1	C-C	C1	C2	1	No	1,421
Bond 2	C-C	C1	C8	1	No	1,421
Bond 3	C-C	C2	C3	1	No	1,421
Bond 4	C-C	C5	C6	1	No	1,421
				1	No	1,421

	Type	Atom 1	Atom 2	Atom 3	Atom 4	Torsion (°)				
Torsion 1	CCCC	C8	C1	C2	C3	57,3553	C1	C2	C3	110,4768
Torsion 2	CCCC	C2	C1	C8	C7	54,8843	C1	C8	C7	-73,7966
Torsion 3	CCCC	C1	C2	C3	C4	-54,8838	C2	C3	C4	-45,8975
Torsion 4	CCCC	C4	C5	C6	C7	57,3557	C5	C6	C7	48,9945
Torsion 5	CCCC	C6	C5	C4	C3	54,8839	C5	C4	C3	65,0440
	CCC					-54,8843	C6	C7	C8	-110,1781
	CCC					-57,3551	C3	C4	C5	-67,1024
	CCC					-57,3556	C7	C8	C1	72,5652

Figure 2: Torsion through c nano tube basic cell of 2 × 2 possible.

Carbon nanotubes (CNTs) hold a great promise in bio-medical applications, such as drug delivery agents, bio-sensors, bone scaffolds materials, and others due to their unique structural, mechanical and electronic properties. It has been reported that the modified CNTs can deliver peptides and ribonucleic acid (RNA) into cells without causing cytotoxicity. Clearly, the studies that obtained good cell viability present some kind of purification (to remove metallic particles dispersed around CNTs and amorphous carbon) or functionalization of the CNT [10].

Experimental and theoretical studies have shown that the thermal conductivity of a carbon nanotube (CNT) is up to several thousand (W/m·K SI: Watt per Meter and Kelvin), showing great potentials in the thermal management area. Many studies have been reported on the use of dispersed CNTs as thermal conducting fillers in a polymer matrix, whose thermal conductivity can be signi.cantly improved by 65–125 percentage (very useful in packaging of electronic devices even at a small loading of CNTs [11].

3. THERMAL STABILITY IN NANO PARTICALS

Magnetic nano particle thermal stability calculation is essential for development of patterned ultra high magnetic storage media. The use of reliable model is very important. The simulation of hysteresis opens a very big opportunities to calculate values of parameters which we then use directly for interpretation of the stability condition of stored information on a nano magnetic structure. The main idea behind that is to change the direction of the applied field H and then see the stability conditions on a given nano bit volume. Research and development teams in companies implementing nano-technology (nano wire, nano particals, nano patterned structurs...etc.) are gaining more and more importance in the field of sensor systems and material science. Demands for the continuous increase in the data storage density bring the challenge to overcome physical limits for currently used magnetic recording media (example). Ferromagnetic nano-particles of different polycrystalline thin films have been formed by heavy or light ion irradiation. Although this modi.cation technique may be a way to produce nano-magnetic particles, there are some critical size limits of nanomagnetic structures like the superparamagnetic limit (SPML) which faces magnetic nanotechnology.

The magnetic properties of thin films are strongly in.uenced by their structure. Small changes in the way a thin film is produced often give rise to large changes in some of the magnetic properties of the thin film. This is best understood by observing how the microstructure of the film changes with processing and then correlating the microstructure directly with the properties of the thin film. The behaviour of magnetic nanoparticles has fascinated materials scientists for decades. There are fundamental limits due to the atomic nature of matter which may impose ultimate physical bounds to nanofabrication and miniaturization. Over the past several decades, amorphous and more recently nano-crystalline materials have been investigated for applications in magnetic devices. The benefit found in the nanocrystalline alloys stem from their chemical and structural variations on a nano-scale which are important for optimizing magnetic recording devices.

4. SUMMERY

Since the discovery of CNTs, they have been the focus of frontier research [6]. It has opened vast areas of research which also include nanoscale reinforcements in composites in order to improve their mechanical, thermal and even electrical properties. Although the focus of the research in nanotube based composites has mostly been on polymer based composites, the unique properties of carbon nanotubes can also be exploited in ceramic matrix composites. But even after a decade of its discovery, the full potential of carbon nanotubes in this application has not been realized with experimental outcomes falling short of predicted values which demand an active insight in this field. Carbon nanofibers and nanotubes are promising to revolutionise several fields in material science and are a major component of nanotechnology. Further market development will depend on material availability at reasonable prices. Nanotubes have a wide range of unexplored potential applications in various technological areas such as aerospace, energy, automobile, medicine, or chemical industry, in which they can be used as gas adsorbents, templates, actuators, composite reinforcements, catalyst supports, probes, chemical sensors, nanopipes, nano-reactors etc. [12].

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