NANO TECHNOLOGY

Abstract:

Think all the way down to one billionth of a meter- a scale at which hydrogen and carbon atoms appear as large as base balls. Now imagine picking up those atoms and arranging them the way we want. At the molecular scale, the idea of holding and positioning molecules is new and almost shocking but it is something, in principle, that can be done. Imagine if we could, by any way, manipulate each and every individual atom of the products. For example, if we rearrange the atoms in coal, we get diamonds. If we rearrange the atoms in sand (and add a pinch of impurities) we get computer chips. That's the basic idea of **nanotechnology**.

The **carbon nanotube** has been crowned the king of nanotechnology due to its unique and remarkable attributes which will enable multitudes of products to be lighter, stronger, cheaper, cleaner, more efficient and more precise in their function. This paper provides an overview of current nanotube technology, with a special focus on the properties of nanotubes in the wider context of materials science and highlights the contribution of our work in this rapidly expanding field. The Carbon Nanotube has been described as a graphitic sheet wrapped to form a seamless cylinder. These small cylinders (nanometers in diameter by microns in length) represent a whole new class of materials, which may one day find many uses in harsh environments or novel applications, where existing materials cannot perform. Ten years ago, the **space elevator** was considered science fiction by most of the space community. With the advent of carbon-nanotube composites and the conclusions of recent studies, the space elevator concept is moving toward mainstream acceptance. The characteristics and the advancement in the space elevator concept using nanotubes are briefly presented.

Key words: Nano tube, small cylinders, the space elevator.

Conclusion: Material Science can be improved with the advent of nano technology. A lot of change in physical and chemical properties can be changed in any material.

Introduction:

"There is a plenty of room at the bottom" is the root cause for this discussion all over. Its all about understanding and control of matter at dimensions of roughly 1 to 100 nanometers (a human hair is approximately 70,000 to 80,000 nm thick) where unique phenomena enable novel applications. It's the era of nanotechnology and we are looking at its endless possibilities. Nanotechnology should really be called "nanotechnologies": There is no single field of nanotechnology. The term broadly refers to such fields as biology, physics or chemistry, any scientific field, or a combination thereof that deals with the deliberate and controlled manufacturing of nanostructures.

The goal of nanotechnology is to manipulate atoms individually and place them in a pattern to produce a desired structure. There are three steps to achieving nanotechnology-produced goods:

1. Manipulating individual atoms. This means that we will have to develop a technique to grab single atoms and move them to desired positions.
2. Developing nanoscopic machines, called assemblers, that can be programmed to manipulate atoms and molecules at will. It would take thousands of years for a single assembler to produce any kind of material one atom at a time. Trillions of assemblers will be needed to develop products in a viable time frame.
3. In order to create enough assemblers, some nanomachines, called replicators, will be programmed to build more assemblers.

Assemblers and replicators will work together like hands to automatically construct products, and will eventually replace all traditional labor methods. This will vastly decrease manufacturing costs, thereby making consumer goods plentiful, cheaper and stronger.

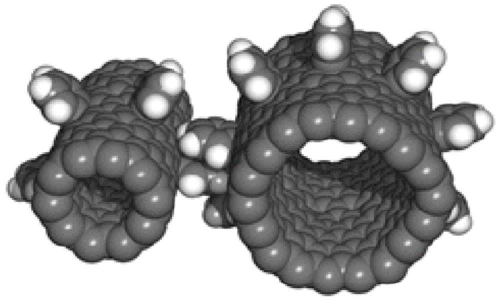


Figure 1: The Nano Gears

What Will We Able To Make?

The fascination about nanotechnology is that we can,

a) Build products with almost every atom in the right place.
b) Do so inexpensively.

What if we could inexpensively make things with every atom in the right place?
This is essential to continue the revolution in computer hardware right down to the molecular gates and wires-something that today's lithographic methods, which are used to make computer chips, could never achieve. Additionally, we could inexpensively make very stronger, lighter, cleaner and more precise materials according to our convenience.

This may include shatterproof diamond in precisely the shapes we want and over fifty times lighter than steel of the same strength. We could make surgical instruments of such precision and deftness that they could operate on the cells and even molecules from which we are made-something well beyond today's medical technology.

The list goes on and on-almost any manufactured product could be vastly improved, often by orders of magnitude. Also the ‘bottom-up’ manufacturing approach-making materials and products from the bottom-up that is, building them up from atoms and molecules-would require less material and create less pollution.

Nanotechnology should let us make almost every manufactured product faster, lighter, stronger, smarter, safer and cleaner. We can already see many of the possibilities as these few examples illustrate. New products that solve new problems in new ways are more difficult to foresee, yet their impact is likely to be even greater. Could Edison have foreseen the computer, or Newton the communications satellite?

1. Improved Transportation:

Today, most airplanes are made from metal despite the fact that diamond has a strength-to-weight ratio over 50 times that of aerospace aluminum. Diamond is expensive, we can't make it in the shapes we want, and it shatters. Nanotechnology will let us inexpensively make shatterproof diamond (with a structure that might resemble diamond fibers) in exactly the shapes we want. This would let us make a Boeing 747 whose unloaded weight was 50 times lighter but just as strong.

Today, travel in space is very expensive and reserved for an elite few. Nanotechnology will dramatically reduce the costs and increase the capabilities of space ships and space flight. The strength-to-weight ratio and the cost of components are absolutely critical to the performance and economy of space ships: with nanotechnology, both of these parameters will be improved. Beyond inexpensively providing remarkably light and strong materials for space ships, nanotechnology will also provide extremely powerful computers with which to guide both those ships and a wide range of other activities in space.

2. Atom Computers:

Today, computer chips are made using lithography -- literally, "stone writing." If the computer hardware revolution is to continue at its current pace, in a decade or so we'll have to move beyond lithography to some new post lithographic manufacturing technology. Ultimately, each logic element will be made from just a few atoms.

Designs for computer gates with less than 1,000 atoms have already been proposed -- but each atom in such a small device has to be in exactly the right place. To economically build and interconnect trillions upon trillions of such small and precise devices in a complex three dimensional pattern we'll need a manufacturing technology well beyond today's lithography: we'll need nanotechnology.

With it, we should be able to build mass storage devices that can store more than a hundred billion billion bytes in a volume the size of a sugar cube; RAM that can store a mere billion billion bytes in such a volume; and massively parallel computers of the same size that can deliver a billion billion instructions per second.

3. Military Applications :

Today, "smart" weapons are fairly big -- we have the "smart bomb" but not the "smart bullet." In the future, even weapons as small as a single bullet could pack more computer power than the largest supercomputer in existence today, allowing them to perform real time image analysis of their surroundings and communicate with weapons tracking systems to acquire and navigate to targets with greater precision and control.

We'll also be able to build weapons both inexpensively and much more rapidly, at the same time taking full advantage of the remarkable materials properties of diamond. Rapid and inexpensive manufacture of great quantities of stronger more precise weapons guided by massively increased computational power will alter the way we fight wars. Changes of this magnitude could destabilize existing power structures in unpredictable ways.

4. Solar Energy :

Nanotechnology will cut costs both of the solar cells and the equipment needed to deploy them, making solar power economical. In this application we need not make new or technically superior solar cells: making inexpensively what we already know how to make expensively would move solar power into the mainstream.

5. Medical Uses:

It is not modern medicine that does the healing, but the cells themselves: we are but onlookers. If we had surgical tools that were molecular both in their size and precision, we could develop a medical technology that for the first time would let us directly heal the injuries at the molecular and cellular level that are the root causes of disease and ill health. With the precision of drugs combined with the intelligent guidance of the surgeon's scalpel, we can expect a quantum leap in our medical capabilities.

Carbon Nanotubes:

Since their discovery in 1991 by Iijima, carbon nanotubes have been of great interest, both from a fundamental point of view and for future applications. The most eye-catching features of these structures are their electronic, mechanical, optical and chemical characteristics, which open a way to future applications. These properties can even be measured on single nanotubes. For commercial application, large quantities of purified nanotubes are needed. Carbon nanotubes are cylindrical carbon molecules with novel properties that make them potentially useful in a wide variety of applications.

A nanotube (also known as a buckytube) is a member of the fullerene structural family, which also includes buckyballs. Whereas buckyballs are spherical in shape, a nanotube is cylindrical, with at least one end typically capped with a hemisphere of the buckyball structure. Their name is derived from their size, since the diameter of a nanotube is on the order of a few nanometers (approximately 50,000 times smaller than the width of a human hair), while they can be up to several centimeters in length.

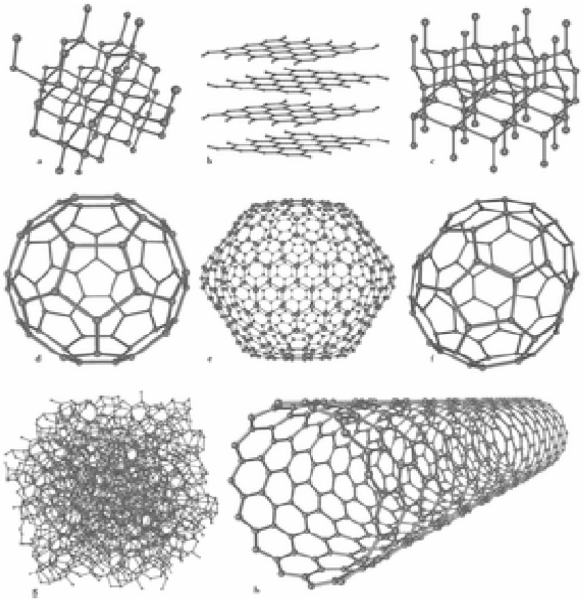


Figure 2: Eight Allotropes Of Carbon: Diamond, Graphite, Lonsdaleite, C60, C540, C70, Amorphous Carbon And A Carbon Nanotube.

There are two main types of nanotubes: single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs). Many exotic structures of fullerenes exist: regular spheres, cones, tubes and also more complicated and strange shapes. Here we will describe some of the most important and best-known structures. Single Walled Nanotubes (SWNT) can be considered as long wrapped graphene sheets. As stated before, nanotubes generally have a length to diameter ratio of about 1000 so they can be considered as nearly one-dimensional structures. More detailed, a SWNT consists of two separate regions with different physical and chemical properties. The first is the sidewall of the tube and the second is the end cap of the tube. The end cap structure is similar to or derived from a smaller fullerene, such as C60.

The other structure of which a SWNT is composed is a cylinder. It is generated when a graphene sheet of a certain size that is wrapped in a certain direction. As the result is cylinder symmetric we can only roll in a discreet set of directions in order to form a closed cylinder. Two atoms in the graphene sheet are chosen, one of which servers the role as origin. The sheet is rolled until the two atoms coincide. The vector pointing from the first atom towards the other is called the chiral vector and its length is equal to the circumference of the nanotube. The direction of the nanotube axis is perpendicular to the chiral vector.

Multi Walled Nanotubes (MWNT) can be considered as a collection of concentric SWNTs with different diameters. The length and diameter of these structures differ a lot from those of SWNTs and, of course, their properties are also very different.

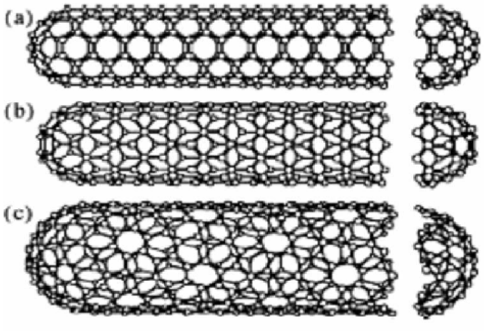


Figure 3: Some SWNTs with different chiralities. The difference in structure is easily shown at the open end of the tubes. a) armchair structure b) zigzag structure c) chiral structures.

Special Properties:

Strength:

Carbon nanotubes are one of the strongest materials known to man, both in terms of tensile strength and elastic modulus. This strength results from the covalent sp2 bonds formed between the individual carbon atoms. In 2000, an MWNT was tested to have a tensile strength of 63 GPa . In comparison, high-carbon steel has a tensile strength of approximately 1.2 GPa. CNTs also have very high elastic modulus, on the order of 1 TPa. Since carbon nanotubes have a low density for a solid of 1.3-1.4 g/cm3, its specific strength is the best of known materials.

The main factor that every material should satisfy is the ratio of density to youngs modulus.The ratio should be as low as possible for the materials. Which implies a low density and high modulus.ie.

$$\boxed{\rho/E \rightarrow \text{low}}$$

Under excessive tensile strain, the tubes will undergo plastic deformation, which means the deformation is permanent. This deformation begins at strains of approximately 5% and can increase the maximum strain the tube undergoes before fracture by releasing strain energy.

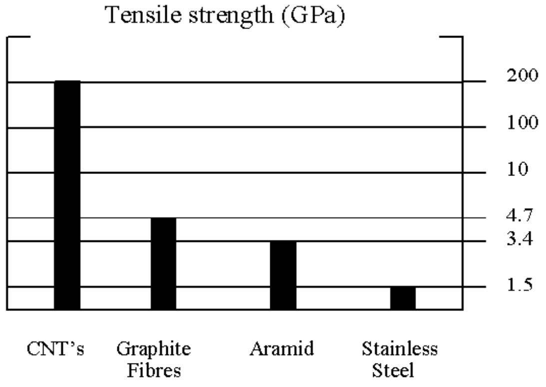
Table 1:Elastic modules and strength of multi wall carbon nanotubes measured by direct tension.

E (Tpa)	0.91
σ (Gpa)	150
F_f (µN)	18
Tube dia.(nm)	12.5

CNTs are not nearly as strong under compression. Because of their hollow structure, they tend to undergo buckling when placed under compressive, torsional or bending stress.

Dynamic Properties:

Multiwalled carbon nanotubes, multiple concentric nanotubes precisely nested within one another, exhibit a striking telescoping property whereby an inner nanotube core may slide, almost without friction, within its outer nanotube shell thus creating an atomically perfect linear or rotational bearing. This is one of the first true examples of molecular nanotechnology, the precise positioning of atoms to create useful machines. Already this property has been utilized to create the world's smallest rotational motor and a nanorheostat. Future applications such as a gigahertz mechanical oscillator are envisioned.



Electrical:

Because of the symmetry and unique electronic structure of graphene, the structure of a nanotube strongly affects its electrical properties. For a given (n,m) nanotube, if 2n + m=3q (where q is an integer), then the nanotube is metallic, otherwise the nanotube is a semiconductor. Thus all armchair (n=m) nanotubes are metallic, and nanotubes (5,0), (6,4), (9,1), etc. are semiconducting.

In theory, metallic nanotubes can have an electrical current density more than 1,000 times greater than metals such as silver and copper.

Thermal:

All nanotubes are expected to be very good thermal conductors along the tube, exhibiting a property known as "ballistic conduction," but good insulators laterally to the tube axis.

Defects:

As with any material, the existence of defects affects the material properties. Defects can occur in the form of atomic vacancies. High levels of such defects can lower the tensile strength by up to 85%. Another well-known form of defect that occurs in carbon nanotubes is known as the Stone Wales defect, which creates a pentagon and heptagon pair by rearrangement of the bonds. Because of the almost one-dimensional structure of CNTs, the tensile strength of the tube is dependent on the weakest segment of it in a similar manner to a chain, where a defect in a single link diminishes the strength of the entire chain.

The tube's electrical properties are also affected by the presence of defects. A common result is the lowered conductivity through the defective region of the tube. Some defect formation in armchair-type tubes (which are metallic) can cause the region surrounding that defect to become semiconducting. Furthermore single monoatomic vacancies induce magnetic properties.

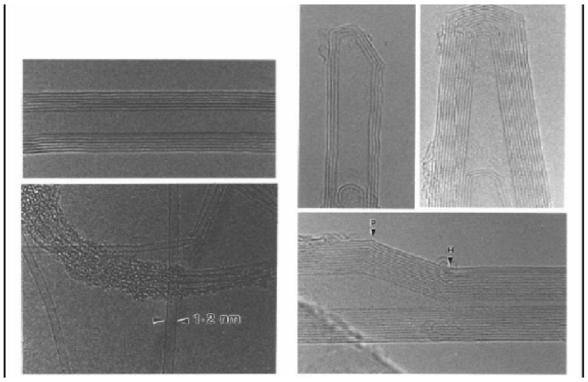


Figure 4: Different structures of MWNTs. Top-left: cross-section of a MWNT the different walls are obvious, they are separated by 0.34nm. Rotation around the symmetry axis gives us the MWNT. Top-right: Symmetrical or non-symmetrical cone shaped end caps of MWNTs. Bottom-left: A SWNT with a diameter of 1,2nm and a bundle of SWNTs covered with amorphous carbon. Bottom-right: A MWNT with defects. In point P a pentagon defect and in point H a heptagon defect

The tube’s thermal properties are heavily affected by defects. Such defects lead to phonon scattering, which in turn increases the relaxation rate of the phonons. This reduces the mean free path, and reduces the thermal conductivity of nanotube structures.

The strength and flexibility of carbon nanotubes makes them of potential use in controlling other nanoscale structures, which suggests they will have an important role in nanotechnology engineering. The highest tensile strength an individual MWNT has been tested to be is 63 Gpa. Bulk nanotube materials may never achieve a tensile strength similar to that of individual tubes, but such composites may nevertheless yield strengths sufficient for many applications. Carbon nanotubes have already been used as composite fibers in polymers and concrete to improve the mechanical, thermal and electrical properties of the bulk product.

Closer to home, much lighter nanotube composites may one day be substituted for steel in cars, thereby reducing weight and yield better fuel economy without compromising

Structural:

Clothes: waterproof tear-resistant cloth fibers

Concrete: In concrete, they increase the tensile strength, and halt crack propagation.

Polyethylene: Researchers have found that adding them to polyethylene increases the polymer's elastic modulus by 30%.

Sports Equipment: Stronger and lighter tennis rackets, bike parts, golf balls, golf clubs, and baseball bats.

Ultrahigh-Speed Flywheels: The high strength/weight ratio enables very high speeds to be achieved.

Chemical:

Air pollution filter: Future applications of nanotube membranes include filtering carbon dioxide from power plant emissions.

Biotech container: Nanotubes can be opened and filled with materials such as biological molecules, raising the possibility of applications in biotechnology.

Water filter: Recently nanotube membranes have been developed for use in filtration. This technique can purportedly reduce desalination costs by 75 percent. The tubes are so thin that small particles (like water molecules) can pass through them, while larger particles (such as the chloride ions in salt) are blocked.

Electromagnetic:

Buckypaper - a thin sheet made from nanotubes that are 250 times stronger than steel and 10 times lighter that could be used as a heat sink for chipboards, a backlight for

Chemical nanowires: Carbon nanotubes additionally can also be used to produce nanowires of other chemicals, such as gold or zinc oxide. These nanowires in turn can be used to cast nanotubes of other chemicals, such as gallium nitride. These can have very different properties from CNTs.

Solar cells: GE's carbon nanotube diode has a photovoltaic effect. Nanotubes can replace ITO in some solar cells to act as a transparent conductive film in solar cells to allow light to pass to the active layers and generate photocurrent.

Future Applications Of Nanotubes:

1. Wire connectors in nanosize computer circuits.
2. Nanosized transistors.
3. Ultraviolet nanosized lasers.
4. Cheap flat screen displays.
5. Very sensitive and inexpensive chemical sensors.
6. Tiny drug delivery systems for the human body.
7. Super strong and light weight materials.

The Space Elevator:

A Technical Reality?

With advances toward ultrastrong nano fibres, the concept of building an elevator 60,000 miles to carry cargo is moving from the realm of science fiction to the fringes of reality?

A space elevator is a theoretical structure designed to transport material from a planet's surface into space. A space elevator is essentially a long cable extending from our planet's surface into space with its center of mass at geostationary Earth orbit (GEO), 35,786 km in altitude. Electromagnetic vehicles traveling along the cable could serve as a mass transportation system for moving people, payloads, and power between Earth and space.

A space elevator would consist of a cable attached to Earths surface, reaching into space. By attaching a counterweight at the end centrifugal force ensures that the cable remains stretched taut, countering the gravitational pull on the lower sections, thus allowing the elevator to remain geosynchronous. Once beyond the gravitational midpoint, carriage would be accelerated further by the planet's rotation.

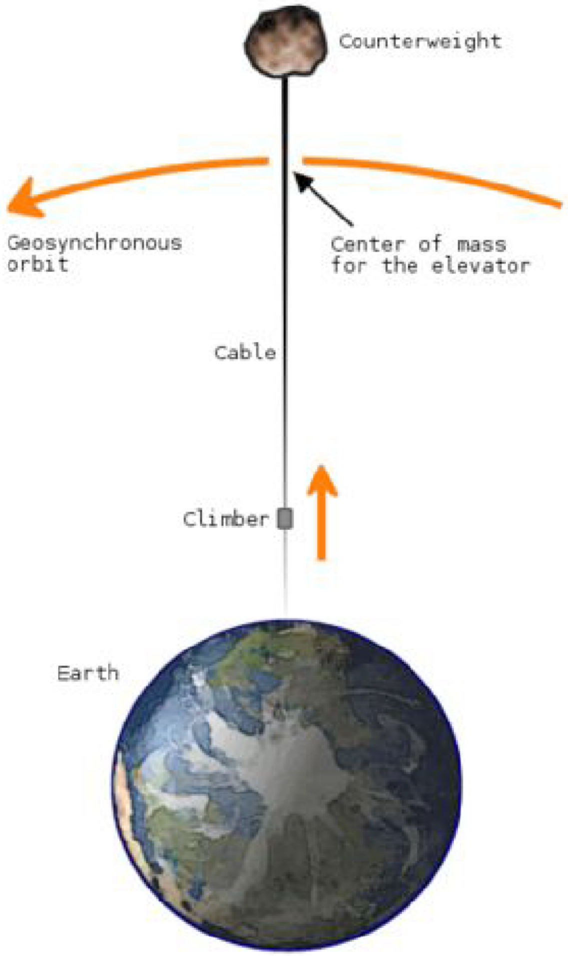


Figure 5: An optimistic view (not to scale)

Fiber materials such as graphite, alumina, and quartz have exhibited tensile strengths greater than 20GPa during laboratory testing for cable tethers. The desired strength for the space elevator is about 62 GPa. Carbon nanotubes have exceeded all other materials and appear to have a theoretical strength far above the desired range for space elevator structures. The development of carbon nanotubes shows real promise, they're lightweight materials that are 100 times stronger than steel.

Monoatomic oxygen in the Earth's upper atmosphere would erode carbon nanotubes at some altitudes, so a space elevator constructed of nanotubes would need to be protected (by some kind of coating). Carbon nanotubes in other applications would generally need no such surface protection.

Meanwhile, testing of prototype space elevator equipment is near at hand. And by far the strongest link that keeps the concept on the straight and narrow is worldwide work now underway by the carbon nanotube research community.

Carbon nanotube fiber is an area of energetic worldwide research because the applications go much further than space elevators. Other suggested application areas include suspension bridges, new composite materials, lighter aircraft and rockets, computer processor interconnects, and so on.