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A Review on Nano Materials of Carbon

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Abstract:-*Nano materials involve research and technology development at the 1nm -100nm range. It creates and uses structures that have novel properties because of their small size. It builds on the ability to control or manipulate at the atomic level. Nano materials are been applied to almost every field imaginable, including electronics, magnetic, optics, information technology, materials development and biomedicine. Because of their small size, nano scale devices can readily interact with molecules on both surface and inside cells. It's a review on nano materials: as to what are nano materials, how are they formed, what is significance of nanoscale, how the properties of materials changes as it enters nanoscale range. What are the tools to prepare nanostructure and preparation of nanomaterials is briefly discussed. To explain properties and applications of nanomaterial's examples like carbon nanotubes and buckyballs are considered. To explain usefulness of nanomaterials in everyday life some applications are discussed*

Keywords: - *synthesis, preparation, nonmaterial's, application*

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I. Introduction

The word "nano" has a Greek origin meaning dwarf (small). Technically, the prefix nano means "one billionth" or 10^{-9}. Therefore one nanometer is 10^{-9}, one nano second is 10^{-9} sec and so on.

Today's wide spread activities in nano science and technology are actually rooted in the ideas of some leading scientists of the last century. Among them, the foremost name was Richard P. Feynman. He delivered a legendary talk entitled "There is plenty of room at the bottom" in the annual general body meeting of the American Physical society on Dec. 29, 1959. at California Institute of Technology. In that talk, the ideas of manipulating and controlling things at the atomic scale were discussed.

Nano materials are defined as those materials which have structured components with size less' than 100nm at least in one dimension. Bulk materials always exhibit macroscopic physical properties. The same material at the nanoscale can have properties (e.g., optical, mechanical, electrical etc) which are very different from the properties of the material that has at the macro scale. Non-intentionally made nano materials, which refers to nano sized particles or materials that belong naturally to the environment (e.g., proteins, virus, nano particles produced during volcanic eruptions,etc.) or that are produced by human activity without intention (such as nano particles produced from diesel combustion, chimney soot etc.). Intentionally produced nano materials, which means nano materials produced deliberately through a defined fabrication process.

Nano science is the study of the fundamental principles of molecules and structures with at least one dimension roughly between 1 and 100 nanometers or it is study of phenomena and manipulation of materials at atomic, molecular and macro molecular scales. Nanotechnology is the principle of manipulation by atom, through control of the structure of matter at the molecular level or is the design, Characterization, production and application of structures, devices and system.

Nanotechnology may also be defined as following-

* Research and technology development at the 1 to 100nm range.
* Creating and using structures that have novel properties because of their small size.
* Ability to control or manipulate at the atomic scale.

Nanotechnology is a rapidly emerging technology with vast potential to manipulate and a substance at the nanometer level (1nm= 10^{-9}m) and create new useful materials and devices with fascinating functions making the best use of the special physical properties of nano sized substances and improved products for numerous applications. It is also concerned with materials and systems whose structures and components exhibit novel and significantly improved physical, chemical and biological properties, phenomena and processes, because of their small nanoscale size. Generally, nano science aims to understand the novel properties and phenomena of all nano-based entities.

II. The Significance of the Nanoscale:

At this scale, atomic classical properties are not applicable but they enter the world of quantum mechanics. The reason for this change over is very simple. The bulk properties of any material are merely the average of all the quantum forces affecting all the atoms. As we make things smaller and smaller, we eventually reach a point where the averaging no longer holds.

The properties of materials are different at the nano scale for two reasons:

1- Nonmaterial's have a relatively large surface area as compared to the same mass of material produced in a larger form. This makes material more chemically reactive and affects their strength as electrical properties.

2- Quantum effects can begin to dominate the behavior of matter at the nanoscale affecting the optical, electrical and magnetic behavior of materials. So, nonmaterial's have unusual electrical, optical and magnetic properties than their bulk Counterpart. So, here we have some interesting examples of kind of changes which are expected in the properties.

i- Opaque substances can become transparent, e.g. copper.
ii- Inert materials can become catalyst e.g. Platinum.
iii- Stable materials can turn Combustible e.g. Aluminum.
iv- Solids can turn into liquid at room temperature e.g. gold.
v- Insulators can become conductors e.g. silicon.

To understand all the above facts, scientists have drawn information from many disciplines. Chemists are generally concerned with molecules, physicists work on the properties of matter which change at the nanoscale very rapidly. So, nanoscale physics plays a very important role in nanotechnology. Engineers are concerned with the understanding and utilization of nanoscale materials. Materials Scientists, electrical engineers, Chemical engineers and mechanical engineers, all deal with the unique properties of nano-structures.

Nanomaterials can be metals, ceramics, polymeric materials or composite materials. Their defining characteristic is very small feature size in the range of 1-100 nanometers. Nanomaterials are not simply another step in miniaturization, but a different arena entirely; the nanoworld lays midway between the scale of atomic and quantum phenomena, and the scale of bulk materials.

Types of nano materials

1. Nanocrystals and clusters(quantum dots)	Diameter 1-10nm	Metals, Semiconductors, Magnetic materials, Ceramic oxides
2. Nanowires and nanotubes	Diameter 1-100nm	Metals, Semiconductors, oxides, sulphides, carbon layer metal chalcogenides
3. 2-dimensional arrays surface and thin films	Several nm^2-pm^2.Thickness 1-1000nm	Metals, Semiconductors, Magnetic materials
4. 3-dimentional arrays(superlattics)	Several nm in all three dimensions	Metals, Semiconductors, Magnetic materials

Table 1.

Typical Nanomaterials are summarized in the above table1, which include
*zero dimension nanostructures-such as metallic, semiconducting and ceramic nanoparticles;
* One dimension nanostructures- such as Nanowires, nanotubes and nanorods;
* Two dimensions nanostructures-such as thin films, magnetic materials.
*Three dimensions Nanomaterials-such as metals, semiconductors, magnetic materials.
* Besides these individual nanostructures- ensembles of Nanostructures form high dimension arrays, assemblies and superlattics.

The structural features of Nanomaterials are in between of those of atoms and the bulk materials. While most micro structured materials have similar properties to the corresponding bulk materials, the properties of materials with nanometer dimensions are significantly different from those of atoms and bulks materials. These properties are mainly due to the nanometer size of the materials which renders them;

i- Large fraction of surface atoms
ii- High surface energy
iii- Spatial confinement
iv- Reduced imperfections, which do not exist in the corresponding bulk materials
.

The 'surface' dependent material properties of Nanomaterials are due to their small dimensions; and have extremely large surface area to volume ratio, which makes a large fraction of atoms of the materials to be the surface or interfacial atoms. Especially when the size of Nanomaterials is comparable to Debye length, the entire material is affected by bulk materials. For example, very active catalysts are obtained from metallic nanoparticles. The sensitivity and sensor selectivity of chemical sensors can be improved by using nanoparticles and Nanowires. The nanometer feature sizes of Nanomaterials also have spatial confinement effect on the materials, which bring the quantum effects. Nanoparticles can be viewed as a zero dimension quantum dot while various Nanowires and nanotubes can be viewed as quantum wires. The profound effects on the properties of Nanomaterials are due to their quantum confinement. The energy band structure and charge carrier density in the materials can be modified quite differently from their bulk count part and in turn will modify the electronic and optical properties of the materials.

Lasers and light emitting diodes from both of the quantum dots and quantum wires are very promising in the future optoelectronics. High density information storage using quantum dot devices is also a fact developing area. Reduced imperfections are also an important factor in determining the properties of Nanomaterials. Nanostructures and Nanomaterials favors of a self purification process in that the impurities and intrinsic material defects will move to near surface upon thermal annealing. This increased material perfection affects the properties of Nanomaterials. For example, the chemical stability for certain Nanomaterials may be enhanced, the mechanical properties of Nanomaterials will be better than the bulk materials. The superior mechanical properties of carbon nanotubes are well known. Due to their nanometer size, Nanomaterials are already known to have many novel properties. Many novel applications of the Nanomaterials rose from these novel properties have also be proposed.

Nanomaterials are corner stone's of nanoscience and technology. Nanomaterials can exist in one dimensions (e.g., surface films), two dimensions (e.g., strands or fibres), or three dimensions (e.g., NsM particles).They can exist in single, fused, aggregated or agglomerated forms with spherical, tabular and irregular shapes.

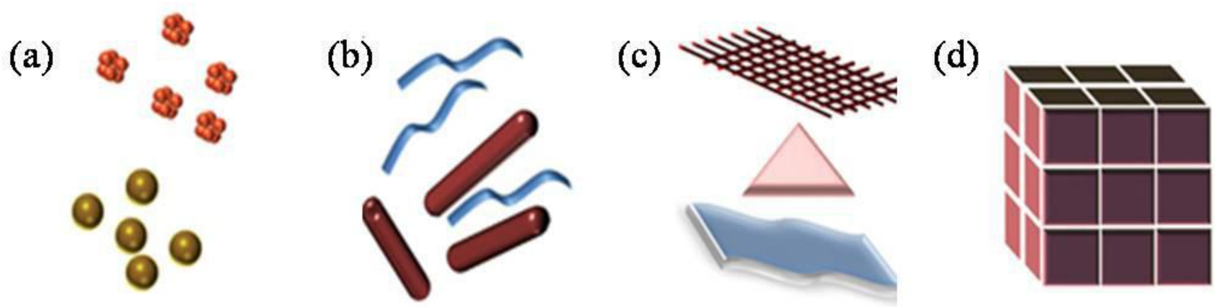

Fig.1 .Classification of Nanomaterials; (a) 0D spheres and clusters, (b) 1D nanofibres, wires and rods(c) 2D films, plates and networks (d) 3D nanomaterials

a) Zero-dimensional nanomaterials- Materials wherein all the dimensions are measured within the nanoscale (no dimensions, or 0D, are larger than 100nm)

The best example of zero-dimensional nanomaterials is nanoparticles. Nanoparticles can:

Be amorphous or crystalline
Be single crystalline or polycrystalline
Be composed of single or multi-chemical elements
Exhibit various shapes and forms
Exist individually or incorporated in a matrix
Be metallic, ceramic, or polymeric

b) One dimensional nanomaterials- Nanomaterials exist in one dimension structure. This lead to needle like shaped nanomaterials.1-D materials includes nanotubes, Nanorods and Nanowires.1-D nanomaterials can be:

Amorphous or crystalline
Single crystalline or polycrystalline
Chemically pure or impure
Stand alone materials or embedded in within another medium
Metallic, ceramic or polymeric

c) Two dimensional nanomaterials-2-D nanomaterials exhibit plate like shapes. Two dimensional nanomaterials include nanofilms, nanolayers and nanocaoting.

2-D nanomaterials can be-
Amorphous or crystalline
Made up of various chemical compositions
Used as a single layer or as multilayer structures
Deposited on a substrate
Integrated into surrounding matrix material

Metallic, ceramic or polymeric

d) Three dimensional nanomaterials- Bulk nanomaterials are materials that are not confined to the nanoscale in any dimension. These materials are thus characterized by having three arbitrarily dimensions above 100nm. Materials possess a nanocrystalline structure or involve the presence of features at the nanoscale. In terms of nanocrystalline structure, bulk nanomaterials can be composed of a multiple arrangement of nanosize crystals most typically in different orientations. In nanoscale, 3-D nanomaterials can contain dispersions of nanoparticles, bundles of Nanowires and nanotubes as well as nanolayers.

III. Tools To Make Nanostructures

A number of tools are used to make nanostructures. Here we shall consider the method of lithography. The word "Lithography" belongs, to the concept on stone. A lithograph is an image (usually on paper) that is produced by making a pattern on the stone, inking the stone & then pushing inked stone onto the paper. We shall consider following lithography.

1. Nanoscale Lithography
2. Dip Lithography
3. E-beam Lithography

1. **NANOSCALE LITHOGRAPHY**: An Nano scale lithography cannot use visible light. The reason is that the wavelength pen of visible light is at least 400 nanometers. Therefore, structure smaller than that are difficult to make directly using it. Indeed, the common methods use X-ray Lithography. For example, current computer chips normally use this Lithography, in this process, a master mask is made using Chemical method and X-rays are passed through that mask to produce the actual chip structure. One of the most straight forward Techniques doing small scale Lithography is micro-imprint Lithography. This method is simple and works as rubber stamp. A pattern is made on the rubber surface (actually a rubber like silicon/oxygen polymer). The rubber surface is coated with molecular ink. The ink can then he stamped out on a metal, polymer, oxide or any other surface in small scale stamps just like a stamp rubber on simple paper.

2. **DIP PEN NANOLITHOGRAPHY**: [DPN] Dip pen nanolithography is a process of writing in the same way as we write ink lines with a fountain pen. In order to make such lines in nanoscale, it is necessary to have a nano pen. Fortunately, an atomic force microscope (AFM) tips are ideal nano pen. Atomic force microscope is a very high resolution type of scanning probe microscope. The scanning probe tip of this microscope is similar to the tip of a fountain pen. This microscope has high resolution of fraction of A_0 i.e. more than 100 times better than optical diffraction limit. In DPN a reservoir of ink (atom as molecules is stored on the top of scanning probe tip). The tip is manipulated across, the surface, leaving lines and patterns behind.

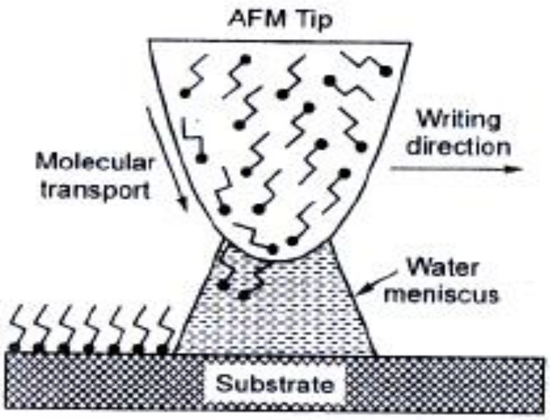

Fig.2

AFM tip are relatively easy to manipulate. This fact makes DPN the techniques of choice for creating new and complex structures in small volumes.

3. **E-BEAM LITHOGRAPHY**: The light based industrial lithography is limited to creating features no smaller than the wavelength used. Although we can use smaller wavelength light but this creates side effects like blowing the features which we are trying to create. The reason is that smaller wavelength light has high energy.

An alternate way to solve the problem is to use electrons instead of light. This E-beam lithography may be used to make structure at nanoscale. E-beam lithography also has applications in current micro electronics manufacturing.

IV. Preparation/Synthesis Of Quantum Dots.

The following two main techniques are used for the preparation of quantum dots.

i- Bottom up Technique

ii- Top down Technique

i **BOTTOM UP TECHNIQUE**: This is a technique in which materials and devices are built up atom by atom, i.e. a technique to collect, consolidate and fashion individual atoms and molecules into the structure. This is carried out by a sequence of Chemical reactions controlled by series of catalysts. This process is used widely in biology. For example, catalysts called enzymes assemble amino acids to construct living tissues that forms and supports the organs of the body.

ii **TOP DOWN TECHNIQUE**: This is a technique in which materials and devices are synthesized as constructed by removing existing material from larger entities. Therefore, in this technique a large scale object or pattern is gradually reduced in technique called Lithography. Lithography is an image that is produced by making a pattern on the inked stone onto the paper. The Lithography used may be a nanoscale Lithography or dip pen lithography or E-beam Lithography. The Lithography shines radiation through a tip to the surface coated with radiation sensitive resist. The resist is then removed and the surface is chemically treated to produce the nanostructure.

The semiconductors like PbS, GaAs, CdS etc. can be synthesized in a nanometer level and they are called as semiconductor or quantum dots. Their properties like band gap, luminescence etc., always differs from their bulk counterpart.

V. Synthesis Of Nanoparticles:

Nano particles with size ranging from 1nm to 100nm can be synthesized by means of various techniques, Physical, Chemical, biological and self-assembly techniques are few common of them .There are six widely known methods used to produce Nano particles, they are:

1. Mechanical alloying or high energy ball milling
2. Sputtering
3. Plasma Synthesis
4. Inert gas Condensation
5. Electro deposition
6. Sol Gel synthesis

Here some of which are discussed below:

1. **BALL MILL METHOD:**

Ball Mill method is a mechanical method. This is a special type of grinder. Ball mill is a cylindrical device used in grinding materials like ores, Chemical, ceramic raw material, etc. The mill rotates round a horizontal axis and is partially filled with material to be grounded plus the grinding medium. Different materials are used as media. Industrial ball mills can operate continuously fed at one end and discharged at the other end. The grinding works on the principle of critical speed. The critical speed is that speed, after which the grinding medium (say balls which is made of chrome steel, stainless steel, ceramic or rubber are responsible for the grinding of particles) start rotating along the direction of a cylindrical device. There will be no further grinding.

2. **Gas Condensation:** Gas condensation was the first technique used to synthesize nanocrystalline metals and alloys. In this technique, metal or inorganic material is vaporized using thermal evaporation sources such as Joule heated refractory crucibles, electron beam evaporation devices, in an atmosphere of 1-50 m bar. In gas evaporation, a high residual gas pressure causes the formation of ultra fine particles (100 nm) by gas phase collision. The ultrafine particles are formed by collision of evaporated atoms with residual gas molecules. Gas pressures greater than 3 mPa (10 torr) are required. Vaporization sources may be resistive heating, high energy electron beams, low energy electron beam and inducting heating. Clusters form in the vicinity of the source by homogenous nucleation in the gas phase grew by incorporation by atoms in the gas phase. It comprises of a ultra high vacuum (UHV) system fitted evaporation source, a cluster collection device of liquid nitrogen filled cold finger scrapper assembly and compaction device. During heating, atoms condense in the super saturation zone close to Joule heating device. The nanoparticles are removed by scrapper in the form of a metallic plate. Evaporation is to be done from W, Ta or Mo refractory metal crucibles [4]. If the metals react with crucibles, electron beam evaporation technique is to be used. The method is extremely slow. The method suffers from limitations such as a source-precursor incompatibility, temperature ranges and dissimilar evaporation rates in an alloy. Alternative sources have been developed over the years. For instance, Fe is evaporated into an inert gas atmosphere (He). Through collision with the atoms the evaporated Fe atoms loose kinetic energy and condense in the form of small crystallite crystals, which accumulate as a loose powder. Sputtering or laser evaporation may be used instead of thermal evaporation [2]. Sputtering is a non-thermal process in which surface atoms are

physically ejected from the surface by momentum transfer from an energetic bombarding species of atomic/molecular size. Typical sputtering uses a glow discharge or ion beam. Interaction events which occur at and near the target surface during the sputtering process in magnetron sputtering has advantage over diode and triode sputtering. In magnetron sputtering, most of the plasma is confined to the near target region. Other alternate energy sources which have been successfully used to produce clusters or ultra fine particles are sputtering electron beam heating and plasma methods. Sputtering has been used in low pressure environment to produce a variety of clusters including Ag, Fe and Si.

Sputter means to split out or throw out and sputtering is a process in which surface atoms are physically ejected from the surface by momentum transfer from an energetic bombarding beam called potential sputtering. Fig 3 shows laser evaporation sputtering in inert gas atmosphere. A high intensity laser beam is allowed to incident on target metal disc. This causes evaporation of atoms from the surface of metal. The atoms are then swept by a burst of helium in vacuum chamber through an orifice. The expansion of gas in vacuum chamber produces a cooling because it has to pass through orifice. Now the cluster of metal atoms as Nano particles are formed in vacuum chamber

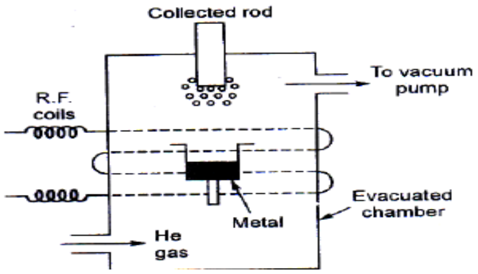

Fig 3

3. **RADIO FREQUENCY (RF) PLASMA (Ionized gas) METHOD:**

Thermal plasma can also deliver the energy necessary to cause evaporation of small micrometer size particles. Fig.4 shows a method of Nano particles synthesis utilizing plasma generated by radio frequency heating coils. The metal is contained in a pestle in an evacuated chamber. The RF coils are wrapped around the evacuated system in the vicinity of the pestle. The evacuated chamber is provided with an opening to enter helium Gas. The evacuated chamber is also provided with a cluster collection device of liquid nitrogen filled cold finger scrapper assembly.

The metal is heated above the evaporation points by R.F. coils. Now helium gas is allowed to pass into evacuated chamber which forms high temperature plasma in the regions of coils. The metal vapor nucleates on the helium gas atoms. It is important to mention here those ultra-fine particles are formed by collision of evaporated atoms with residual gas molecules. They now diffuse to colder collector rod where Nano particles are formed.

4. **CHEMICAL METHOD: Chemical vapor Deposition (CVD) and Chemical vapor condensation (CVC)**

CVD is a process in which a solid is deposited on a heated surface by a chemical reaction from the vapor or gas phase.CVC reaction requires activation energy to proceed. This energy can be provided by several methods. In thermal CVD the reaction is activated by high temperature above 900^oC. A typical apparatus comprises of gas supply system, deposition chamber and an exhaust system. In plasma CVD, the reaction is activated by plasma at temperatures between 300-700^oC. In laser CVD, pyrolysis occurs when laser thermal energy heats an absorbing substrate. In photo laser CVD, the chemical reaction is induced by ultra violet radiation which has sufficient photon energy to break the chemical bond in reactant molecules. In this process, the reaction is photon activated and decomposition occurs at room temperature. Nano composite powder has been prepared by CVD. SiC/Si_3N composite powder was prepared using SiH_3, CH_4, WF_6 and H_2 as a source of gas at 1400^oC. Another process called chemical vapor condensation (CVC) was developed in Germany in 1994. It involves pyrolysis of vapors of metal organic precursors in a reduced pressure atmosphere. Particles of ZrO_2, Y_2O_3 and nanowhiskers have been produced by CVC method. A metallorganic precursor is introduced in the hot zone of the reactor using mass flow controller. For instance, hexamethyldisilane $(CH_3)_3SiNHSi(CH_3)_3$ was used to produce SiCxNyOz powder by CVC technique. The reactor allows synthesis of mixtures of nanoparticles of two phases or doped nanoparticles by supplying two precursors at front end of the reactor and coated nanoparticles, n –ZrO_2, coated with n-Al_2O_3 by supplying a second precursor in a second stage of reactor. The process yield quantities in excess of 20 g/hr. The yield can be further improved by enlarging the diameter of hot wall reactor and mass of fluid through the reactor. Typical nanocrystalline materials which have been synthesized are shown in table 2 below

Precursors	Product powder	Phase as prepared	Average particle size(nm)	Surface area(m^2/g)
$(CH_3)_3SiNHSi(CH_3)_3$	SiCxNyOz	amorphous	4	377
$Si(CH_3)_4$	SiC	β-phase	9	201
$Al[2\text{-}OC_4H_9]_3$	Al_2O_3	Amorphous	3.5	449
$Ti[I\text{-}OC_3H_7]_4$	TiO_2	Anatase	8	193
$Si[OC_2H_5]_4$	SiO_2	Amorphous	6	432
$Zr[3\text{-}OC_4H_9]_4$	ZrO_2	Monoclinic	7	134

Table-2 Typical nanocrystalline materials synthesized by the CVC method

The nano particles of Ag can be prepared by decomposing $(CH_3)_2$ - $C_2H_5NaAlH_3$ in toluene and heating the solution to 105°C for two hours. The Titanium isopropoxide is also added to act as catalyst. The size of the particles produced depends on the choice of catalyst. For example, in presence of Titanium as Catalyst 80nm particles are produced.

5. PULSED LASER ABLATION: The principle of laser ablation has been described in several papers. Laser ablation means the removal of material from a surface by means of laser irradiation. The term “laser ablation” is used to emphasize the nonequilibrium vapor/plasma conditions created at the surface by intense laser pulse, to distinguish from “laser evaporation,” which is heating and evaporation of material in condition of thermodynamic equilibrium. A typical schematic diagram of laser ablation is shown in the following figure. Briefly, there are two essential parts in the laser ablation device, a pulsed laser (CO_2 laser, Nd-YAG laser, ArF excimer laser, or XeCl excimer laser) and an ablation chamber. The high power of the laser beam induces large light absorption on the surface of target, which makes temperature of the absorbing material increase rapidly. As a result, the material on the surface of target vaporizes into laser plume. In some cases, the vaporized materials condensate into cluster and particle without any chemical reaction. In some other cases, the vaporized material reacts with introduced reactants to form new materials. The condensed particle will be either deposited on a substrate or collected through a filter system consisting of a glass fiber mesh. Then, the collected nanoparticle can be coated on a substrate through drop-coating or screen-printing process.

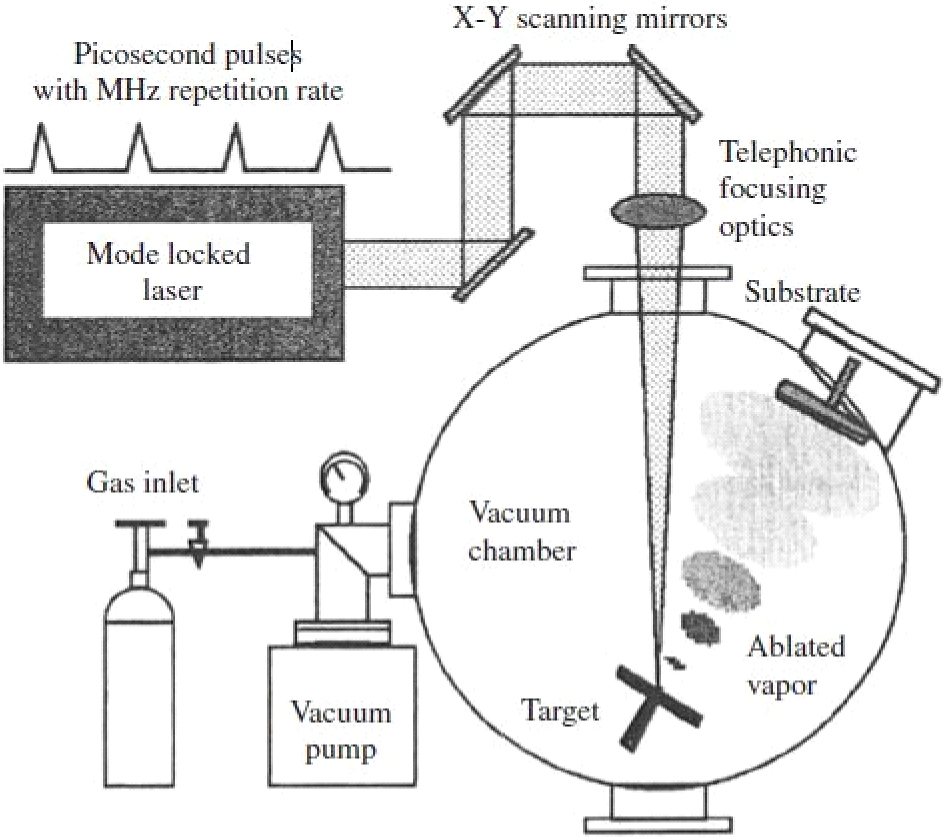

Fig 4

Williams and Coles prepared nanocrystalline SnO_2 by a laser ablation technique for detection of CO, H_2, and CH_4. Their studies revealed that the gaseous atmosphere in which the condensation of the laser-ablated SnO_2 occurs has a significant influence on the size of the nanoparticles generated. The use of Ar at the pressure of 1 mbar to replace the standard conditions employed in air at 1 bar led to a decrease in SnO2 grain size to 8 nm. Furthermore, by shortening the laser pulse from the customary 20 ms to 30 ns by employing a XeCl excimer laser, a further reduction in the grain size was achieved. Their gas sensors based on nanocrystalline SnO_2 powders prepared by laser ablation and gas-phase condensation route offered enhanced sensitivity to CO, H_2, and CH_4 compared with the materials prepared by conventional methods. Hu and his co-workers prepared nanocrystalline SnO_2 thin film using a SnO_2 target and a metallic Sn target respectively for C_2H_5OH detection. Their results demonstrated that the oxidation of Sn into SnO_2 depends strongly on the substrate temperature. Oxidation of Sn into SnO_2 proceeds mainly on the substrate surface instead of in the ablation plume during the condensation of Sn species onto the substrate, even if the ambient oxygen pressure reaches 100–150 Pa. Recently, Starke and Coles reported their gas sensors prepared using laser ablated nanocrystalline metal oxides. They found that SnO_2 and In_2O_3 are capable of detecting ozone at concentrations well below 100 ppb with response times of less than one minute. Pt doped SnO_2 and, particularly, In_2O_3 show some cross sensitivity to NO and NO_2. WO_3 shows sensing properties superior to these two materials in terms of selectivity and response time but regrettably does not exhibit such high sensitivity. Their CO sensor is highly sensitive to single-figure ppm concentration with a resolution down to 1 ppm. These studies demonstrate that the laser ablated Nanostructured metal oxides can greatly enhance the sensing performance of gas sensors.

This method is used in the synthesis of Ag Nano particles. Ag NO_3 Solution and a reducing agent are arranged in a vessel. A solid disc attached with a rotating device is placed inside the solution with the help of motor. This disc is subjected to pulses from laser beam. The pulse of laser beam produces hot spots on the surface of the disc. The reaction of $AgNO_3$ and reducing agent at these hot spots result in the formation of silver Particles. These particles are separated from solution by centrifuge. The size of the particles depends on the energy of incident laser pulses as well as on the rotation speed of disc.

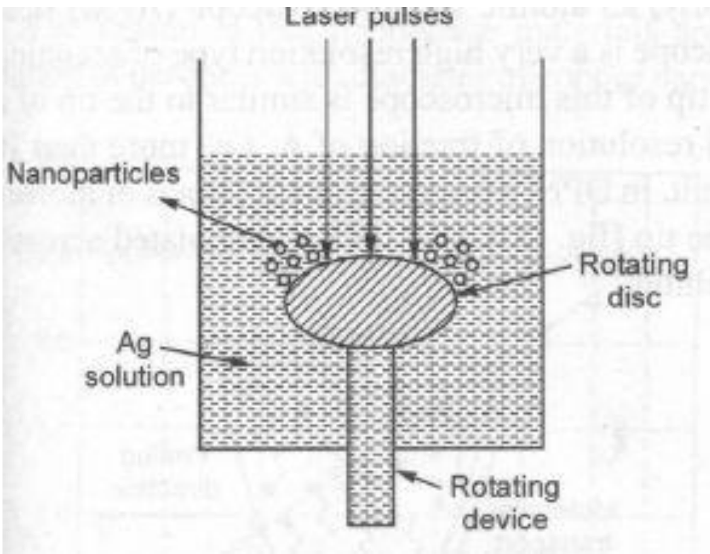

Fig.5

VI. Sol Gel Method

In addition to techniques mentioned above, the sol-gel processing techniques have also been extensively used. Colloidal particles are much larger than normal molecules or nanoparticles. However, upon mixing with liquid colloids appear bulky whereas the nanosized molecules always look clear. It involves the evolution of networks through the formation of colloidal suspension (sol) and gelatin to form a network in continuous liquid phase (gel). The precursor for synthesizing these colloids consists of ions of metal alkoxides and aloxysilanes. The most widely used are tetramethoxysilane (TMOS), and tetraethoxysilanes (TEOS) which form silica gels. Alkoxides are immiscible in water. They are organo metallic precursors for silica, aluminum, titanium, zirconium and many others. Mutual solvent alcohol is used. The sol gel process involves initially a homogeneous solution of one or more selected alkoxides. These are organic precursors for silica, alumina, titania, zirconia, among others. Mortia et al [11-14] a catalyst is used to start reaction and control pH. Sol-gel formation occurs in four stages.

Hydrolysis
Condensation
Growth of particles
Agglomeration of particles

Hydrolysis

During hydrolysis, addition of water results in the replacement of [OR] group with [OH-] group. Hydrolysis occurs by attack of oxygen on silicon atoms in silica gel. Hydrolysis can be accelerated by adding a catalyst such as HCl and NH3. Hydrolysis continues until all alkoxy groups are replaced by hydroxyl groups. Subsequent condensation involving silanol group (Si-OH) produced siloxane bonds (Si-O-Si) and alcohol and water. Hydrolysis occurs by attack of oxygen contained in the water on the silicon atom.

Condensation

Polymerization to form siloxane bond occurs by either a water producing or alcohol producing condensation reaction. The end result of condensation products is the formation of monomer, dimer, cyclic tetramer, and high order rings. The rate of hydrolysis is affected by pH, reagent concentration and H2O/Si molar ratio (in case of silica gels). Also ageing and drying are important. By control of these factors, it is possible to vary the structure and properties of sol-gel derived inorganic networks.

Growth and Agglomeration

As the number of siloxane bonds increase, the molecules aggregate in the solution, where they form a network, a gel is formed upon drying. The water and alcohol are driven off and the network shrinks.

At values of pH of greater then 7, and H2O/Si value ranging from 7 to 5. Spherical nano-particles are formed. Polymerization to form siloxane bonds by either an alcohol producing or water producing

2 HOSi (OR)3 → (OR)3 Si O Si (OR)3 + H2O

or

2 HOSi (OR) 3 → (OR)2 OH Si O Si (OR)3 + H2O

Above pH of 7, Silica is more soluble and silica particles grow in size. Growth stops when the difference in solubility between the smallest and largest particles becomes indistinguishable. Larger particles are formed at higher temperatures. Zirconium and Yttrium gels can be similarly produced.

Despite improvements in both chemical and physical methods of synthesis, there remain some problems and limitations. Laser vaporization technique has offered several advantages over other heating techniques. A high energy pulsed laser with an intensity flux of 106 - 107 W/cm2 is forced on target material. The plasma causes high vaporization and high temperature (10,000°C). Typical yields are 1014-1015 atoms from the surface area of 0.01 cm2 in a 10-8 s pulse. Thus a high density of vapor is produced in a very short time (10-8 s), which is useful for direct deposition of particles.

7 Electrodeposition

Nanostructured materials can also be produced by Electrodeposition. These films are mechanically strong, uniform and strong. Substantial progress has been made in Nanostructured coatings applied either by DVD or CVD. Many other non-conventional processes such as hypersonic plasma particle deposition (HPPD) have been used to synthesize and deposit nanoparticles. The significant potential of nanomaterial synthesis and their applications is virtually unexplored. They offer numerous challenges to overcome. Understanding more of synthesis would help in designing better materials. It has been shown that certain properties of Nanostructured deposits such as hardness, wear resistance and electrical resistivity are strongly affected by grain size. A combination of increased hardness and wear resistance results in a superior coating performance.

8. **Arc Discharge Process**- Carbon nanotubes and Fullerenes are formed during carbon soot formation in arc discharge process. The high temperature caused by discharging caused the carbon contained in the negative electrode to sublime and CNTs are deposited on the opposing electrode. CNTs produced by this method were initially multi walled tubes.

Nanomaterials categories

Nanomaterials are also classified into ten main categories in order to give a good overview of the different nanomaterials. The main material categories are defined as:

1. Nanotubes-carbon based nanomaterials
2. Nanocomposites
3. Metals and alloys
4. Biological nanomaterials

In addition on the basis of phase composition, nanomaterials in different phases can be classified as,

- Single phase solids include crystalline, amorphous particles and layers, etc.
- Multi phase systems include colloids, aero gels, ferro fluids

6**. Examples of nanomaterial's:**

1. **CREATION AND USE OF BUCKYBALL:**

Until 1985, there were only two known forms of pure Carbon graphite and diamond. Both these substances consist entirely of carbon atoms. However, they differ greatly in their structures and physical properties. First of all we shall discuss the structure of diamond and graphite.

2. **DIAMOND:**

In diamond all carbon atoms are stacked neatly in a three dimensional array or lattice. Each carbon atom is bound to four other carbon atoms in a pattern of tetrahedrons. This structure is extremely hard Fig. (6). shows the structure of diamond.

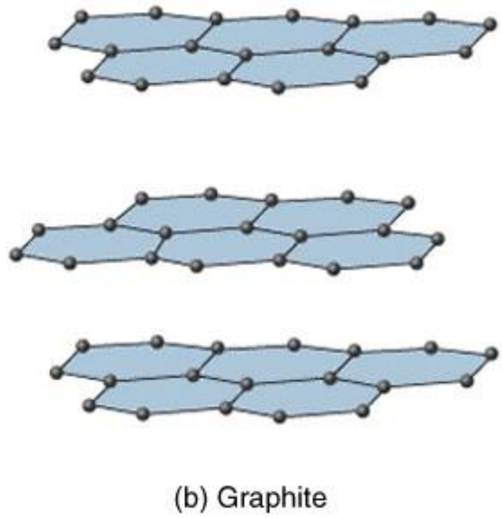

Fig.6 **Fig.7**

6.2. **GRAPHITE:**

In Graphite, the carbons atoms form sheet of linked hexagons. Each carbon atom within a sheet forms strong bonds to three other carbon atoms. However, the sheets are held together by weak bonds due to vanderwaal's forces. This means that sheets can slide over each other. Therefore, graphite is soft and greasy. Fig (7) show the structure of carbon atoms connected by covalent bonds in a sheet of graphite.

In 1985, a third form of carbon was discovered. It is a hallow cluster of 60 carbon atoms shaped like a football. Just like the case of graphite, in which each carbon atom is bonded to three adjacent carbon atoms and arranged in a sphere about a nano meter in diameter. It was named, Buckminister fullerene or in short buckyballs after the famous American R. Buckminister Fuller who had already, designed domes in the structures. The shape of a buckyball is shown in fig. (8) Buckyballs is the roundest and most symmetrical large molecule known in the world. The buckyballs has carbon atoms at 60 chemically equivalent vertices that are connected by 32 faces 12 of which are pentagonal and 20 hexagonal. Today a whole family of related molecules has been discovered and comes under fullerenes.

Larger buckyballs such as C70, C76, C70 and C84 have also been found. In addition to it, smaller Bucky-balls C20, C22, and C36 have also been identified.

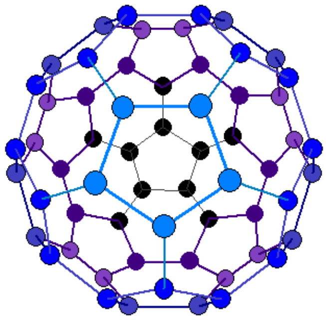

Fig. 8

6.3. CREATING OF BUCKYBALLS:

Buckyballs are created by vaporizing carbon placed between two graphite rods which are placed in low pressure Helium atmosphere in a reaction chamber. An arc is produced; tremendous energy is created which is transferred to carbon. The carbon is evaporated as dust. It is mixed with a solvent and a mixture of fullerenes is formed which can be separated by distillation, fractional distillation or chromatography.

6.3.1. PROPERTIES:

1. Buckyballs are stable and withstand very high temperature and pressure.
2. The carbon atoms of buckyballs can react with other atoms and molecules leaving the stable, spherical structure still intact.
3. Buckyballs do not bond to each other they however stick together via Vander Waal forces.
4. New molecules can be created by adding other molecules to the outside of a buckyballs and by trapping smaller molecule inside a buckyballs.

6.3.2. USES:

Most of the commercial applications of buckyballs are still under developing stages. However various places where buckyballs can be used are:

1. When a buckyballs is doped by inserting the right amount of potassium or cesium into empty spaces within the crystal, it becomes a super conductor.
2. Almost every carbon atom in C_{60} can absorb hydrogen atom which suggest that buckyballs can be used as a better storage medium for hydrogen fuel than metal hydrides.
3. Buckyballs can deliver medicine directly to the infected regions of the body, they are involved in delivering elements for medical imaging, and they have ability to act as antioxidants on counter acting free radicals in the human body. Researchers are modifying buckyballs to fit the section of the HIV molecule that binds to proteins, possibly inhibiting the spread of virus.
4. Making bullet proof vests with inorganic (tungsten disulphide) buckyballs.
5. Buckyballs combing with nanotubes and polymers are used to produce expensive solar cells that can be formed by simply painting the surface.
6. Buckyballs based light detector is developed.
7. Buckyballs are being used for production of diamonds and carbides as cutting tools or hardening agents.
8. Buckyballs can be used to reduce the growth of bacteria in pipes and membranes in water system.
9. The antioxidant properties of buckyballs may be able to fight the deterioration of motors function due to multiple sclerosis.

VII. Carbon Naotubes:

In 1990, Richard Smalley gave the concept if buckyballs get big enough then they can become carbon cylinders. Sumio Lizima discovered these cylinders in 1991 and named them nano tubes. Carbon nano tubes are a sheet of graphite rolled into a tube with bonds at the end of the sheet that close. The tube dimensions are variable and can be as small as 0.4nm in diameter & several millimeters in length. CNTs have a length to diameter ratio greater than 10,00,000. Fig 7 gives structure of carbon nano tube.

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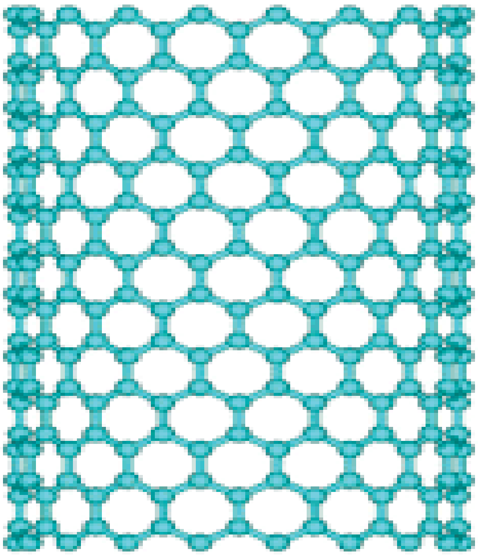

Fig 9

7.1. **TYPES OF NANOTUBES**:

There are two main types of nano tubes;

- Single walled nano tubes (SWNTs) and Multi walled nano tubes (MWNTs).

7.2. STRUCTURE:

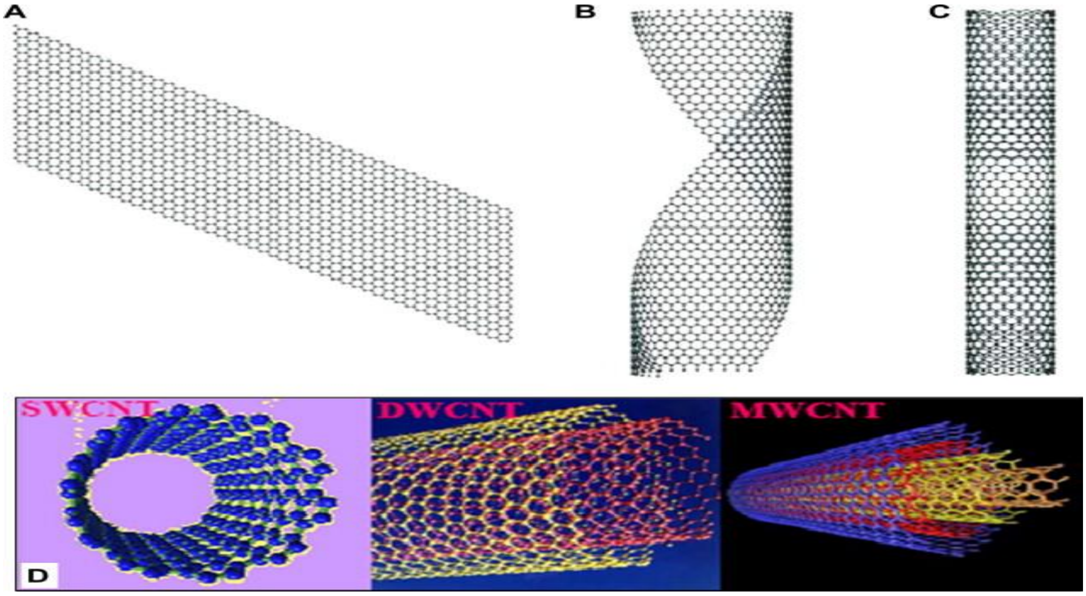

Fig 10

Fig.10 gives the structure of SWCNT AND MWCNT. The diameter of most single walled nanotubes is close to 1 nanometer with a tube length of many million times longer. A one atom thick layer of graphite is wrapped into a seamless cylinder to give the structure of SWNT. Multiwall carbon nano tubes consist of multiple concentric nano tube cylinders i.e. they consist of multiple layers of graphite rolled in on themselves to form a tube shape. A carbon nano tube is a cylinder of carbon atoms covalently bonded together some of these cylinders are closed at the ends and some are open. Each carbon atom is bonded to three other carbon atoms and forms a lattice in the shape of hexagons except near the end. For nano tubes with closed ends, where the ends start to curve to form a cap, the lattice forms pentagons.

Depending on the direction of roll up of graphite hexagons, carbon nano tube can be classified as either Zigzag, armchair or Chiral as given in Fig 11.

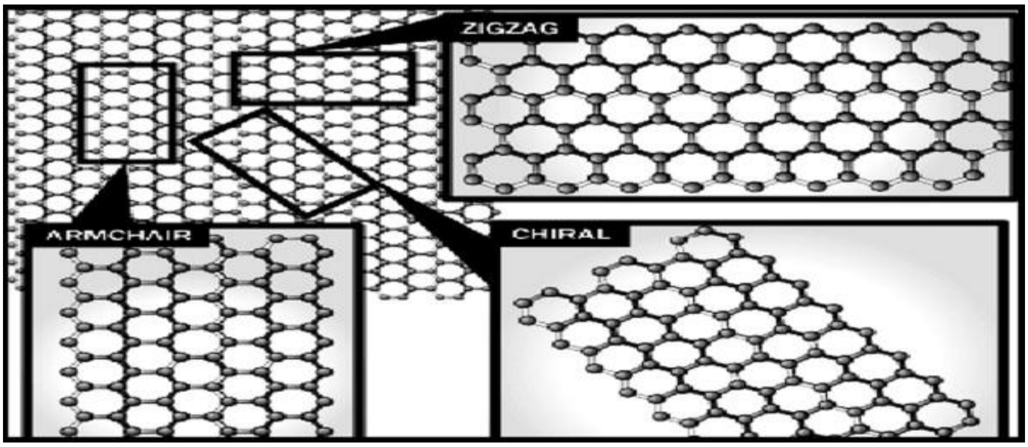

Fig 11

The structure of Nano tube can be specified by chiral vector (n, m). Which define how the graphite sheet is rolled up n and m are integers if the vector equation-

$$R= na1 + ma2$$

The values of n and m determine the Chirality or twist of the Nano tube.

i- If m = 0, then the CNT is called Zigzag.

ii- If n = m then the Nano tube is called armchair

iii- For any other combination of n and m, Nano tubes are called Chiral.

7.4. **SYNTHESIS OF NANOTUBES**: Some methods of preparation of carbon Nano tubes are as given below

1. **Carbon arc method**: Carbon Nano tubes and fullerenes are formed during carbon soot formation in arc discharge process. The high temperature caused by the discharge causes the carbon contained in the negative electrode to sublime and the CNTs are deposited on the opposing electrode CNTs produced by this method were initially multiwall tubes (MWNTs). However, vaporized carbon in the presence of cobalt can grow SWNTs. Mixtures of components are produced in this method and requires further purification to separate the CNTs from the soot and the residue catalytic metals. Producing CNTs in high yield depends on the uniformity of the Plasma, arc and the temperature of the deposit forming on the carbon electrode.
2. **Dual pulsed laser Method**: Dual pulsed laser Method produces pure SWCTs with high yield. With direct vaporization of a Co/Ni doped graphite rod with a high powdered laser in a Tube furnace operating at 1200^o SWCTs can grow easily the material produced by this method appears as mat of ropes 10-20nm in diameter and up to 100 um or more in length. Each rope consists of a bundle of SWNTs, aligned along a common axis. By varying the process parameters such as catalyst composition and the growth temperature the average Nano tube diameter and size distribution can be varied.
   The arc discharge and laser vaporization techniques have drawbacks for the synthesis of small quantities of high quality SWNTs; the first is that they involve evaporation of carbon source, making scale up on an industrial level difficult and energetically expensive. The second issue relates to the fact the vaporization methods grow. SWNTs. in highly tangled forms, mixed with unwanted forms of carbon. The SWNTs, thus produced are difficult to purify manipulate and assembly for building Nano tube device architectures for practical applications.
3. **Chemical Catalysis Method**: In this method catalytic vapor decomposition of hydrocarbon is done to produce carbon fibers. During CV D a substrate is prepared with a layer of metal Catalyst particles. Pyrolysis of hydrocarbons in the presence of metal catalyst can generate MWNTs and SWNTs. MWNTs are produced at lower temperature (300-800oC) in an inert gas atmosphere and SWNTs are generated at higher temperature (600-1150^{o}C) with a mixture of hydrogen and an inert gas like Ar being present in the chamber.
4. **Vapor Liquid Solid Growth Method**: Large scale production of Nano tubes can be done by vapor, liquid solid growth. The carbon containing gas, is broken apart at the surface of the catalyst particle in VLS growth method, and the carbon is transported to the edges where it forms Nano tubes at the sites of metal Catalyst. The length of the tube grown in surface supported catalyst VLS system appears to be dependent on the orientation of the growing tube with the surface. By properly adjusting the surface concentration and aggregation of the catalyst particles it is possible to synthesize vertically aligned carbon Nano tubes i.e. as a carpet perpendicular to the substrate.

7.5. PROPERTIES OF NANOTUBES:

1. Carbon Nano tubes are super strong. The tensile strength of carbon Nano tubes is 100 times greater than steel. This is due to the fact that firstly, each carbon nanotubes are one large molecule and secondly the strength provided by the interlocking carbon to carbon covalent bonds is very large.
2. Nano tubes are very elastic. The young modules of nanotubes are 5 times higher than for steel. This is due to the fact that Nano tubes have a perfect structure and bond strength between carbon atoms is very strong.
3. In addition to being strong and elastic, carbon Nano tubes are light weight with a density about one quarter that of steel.
4. The thermal conductivity of Nano tube is very high. Conduction in Nano tubes takes place due to vibration of covalent bonds holding the carbon atoms together.
5. A carbon Nano tube happens to be a non-polar molecule.
6. The carbon Nano tubes show negative magneto resistance (Phenomenon of change in resistance of a material due to valuation in D.C. magnetic field).
7. Carbon Nano tubes are metallic as semiconducting depending upon the diameter and how they are rolled. The synthesis of carbon Nano tubes generally results in a mixture of tubes, two thirds are semiconducting and One third is metallic.

7.6. Applications. Nano tubes have large number of application some are given below:

1. Due to its unusual current conduction mechanism, wires made from Nano tubes can conduct huge amount of current with less power wastage.
2. Nano tube based transistors can operate at room temperature and are capable of digital switching using a single election.
3. Due to its great mechanical properties, Nano tubes can be used to produce from every day, items like clothes, sports gear to combat bullet proof jackets & space suits.
4. Using Nano scales, Nano scale electric motors are used.
5. Chemical vapors are also being detected using Nano tubes.
6. Research is being done to store hydrogen in Nano tubes if successful this would act us a fuel tank for hydrogen fuel cell powered cars.
7. In medical applications, the carbon Nano tube can be used as a vessel for transporting drugs into the body. It is especially being used for treatment of cancer in destroying cancer cells.

VIII. Applications Of Nano Technology:

1. In Device Technology: Nano materials with less than 100nm size are used in microprocessors in electronic industry - smaller size allow faster processing time and also more processing power to be packed into a given area.

a. Biochips-Biochip is a miniaturized device that can be used for multiplexing, enabling analysis of different DNA/proteins simultaneously.

b. BioNEMs- Nanoelectro mechanical systems are nanoscopic devices less than 100nm in length. The NEMs fabricated with new nanomaterials acts as biofunctionalized Nanoelectro mechanical systems.

2. In Health and Medicine: Nanotechnology has its applications in field of health and medicine. The approach ranges from the medical use of Nano materials to Nano electronic biosensors and even possible future application of molecular nanotechnology. Nano medicine has the potential to enable early detection and prevention and to essentially improve diagnosis, treatment and follow up of diseases. A list of some applications of nanomaterials to biology and medicine is listed below-

a. Fluorescent biological labels
b. Drug and gene delivery
c. Biodetection of pathogens
d. Detection of protein
e. Tissue engineering
F.Tumour destruction
g. Separation and purification of biological molecules and cells.
h. MRI contrast enhancement

3. **In Transportation**: Nano materials will make car and planes to become safer & cheaper-light Nano materials replace heavy weight structural materials.

* Reduce pollution
* Cerium Oxide Nano particles are used in diesel fuel to increase fuel efficiency.

4. **In energy and Environment**: Nanotechnology will provide sufficient energy for growing world to protect environment in which we live

* Carbon Nano tubes fuel cell are being used to store hydrogen.
* By Nano porous filter Combustion engine pollutants can be reduced.
* Reduce energy Consumption.

5. **In Space Exploration**: Rocket scientists are actively researching new forms of space propulsion systems because today's rocket engine rely on chemical propulsion.

* Space Structure can be made much lighter and more viable
* Performance can increase using solar powered ion engines with nanotechnology.

6. **In Optics**: Electric light and fluorescent lights are in common use. Nano science has entered in the field of light emission by the use of light emitting diode (LED).
7. **Therapeutics-** Nanotechnology aids in delivery of just the right amount of medicine to the exact spot of the body that need it. Drug and gene delivery system includes organic, inorganic, and polymeric and lipid based nanobiomaterials. These nanobiomaterials could further be engineered to be stimuli-responsive.
8. **Water**: Nanotechnology will provide efficient water purification techniques Water from the oceans can also be converted into drinking water.
9. **Sensors**: based on nanotechnology are more sensitive and more effective.
10. **Computers:** can be made more powerful and smaller using nanotechnology.
11. Dendrimers are nanomaterials consisting particles between 1-100nm, they have applications in engineering, industry, pharmaceuticals etc. For example Manganese dendritic nanoparticles developed as MRI contrast agent increase hydrophobicity and relaxivities.
12. Bioimaging/ Molecular imaging-The use of nanoparticles has boosted the development of diagnostic agents for bioimaging. It of increased attention has been devoted to the development of nanoparticles as multimodel agents for diagnosis, imaging and theory. For example Quantum dots are used in optical imaging, for example SPIO nanoparticles are used for bioimaging applications

IX. Conclusion

Nano materials involve research and technology development at the 1nm -100nm range. It creates and uses structures that have novel properties because of their small size. It builds on the ability to control or manipulate at the atomic level. Nano materials are been applied to almost every field imaginable, including electronics, magnetic, optics, information technology, materials development and biomedicine. Because of their small size, nano scale devices can readily interact with molecules on both surface and inside cells. However, there is a concern that the unique properties of nano materials might pose substantial risks, which have been largely unexplored, to both human health and the environment. Moreover, understanding issues related to current technologies will serve to promote less harmful and safer alternative technologies for the future.

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