NANO MATERIALS

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- *Thin films*
- *Carbon Nano Tubes*
- *Bucky Balls*
- *Applications of Nano technology*

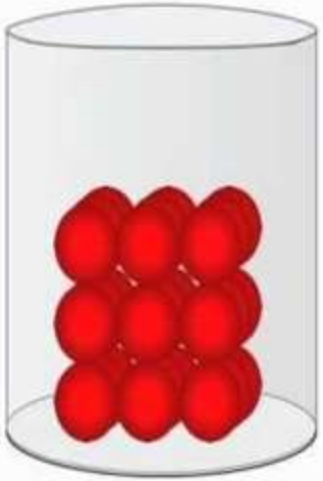
MATTER

Anything that have mass, volume and occupy space is called matter. *Matter is made up of very tiny* ***"particles"***

Thus, matter can be classified into different categories based on the physical properties

- **Solid**
- **Liquid**
- **Gas**

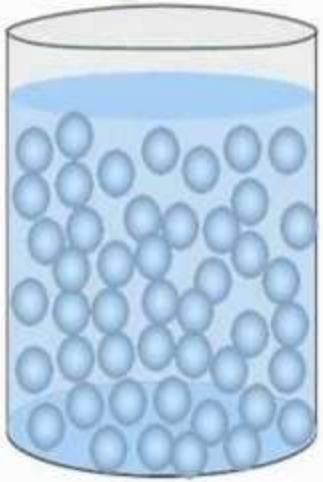
solid



- rigid
- fixed shape
- fixed volume

cannot be squashed

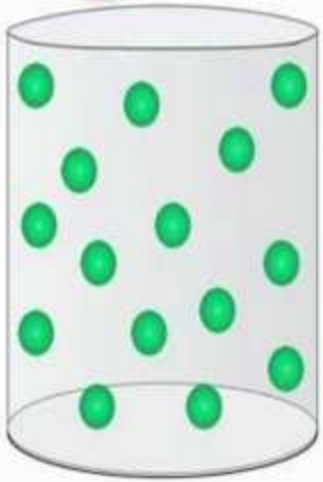
liquid



- not rigid
- no fixed shape
- fixed volume

cannot be squashed

gas



- not rigid
- no fixed shape
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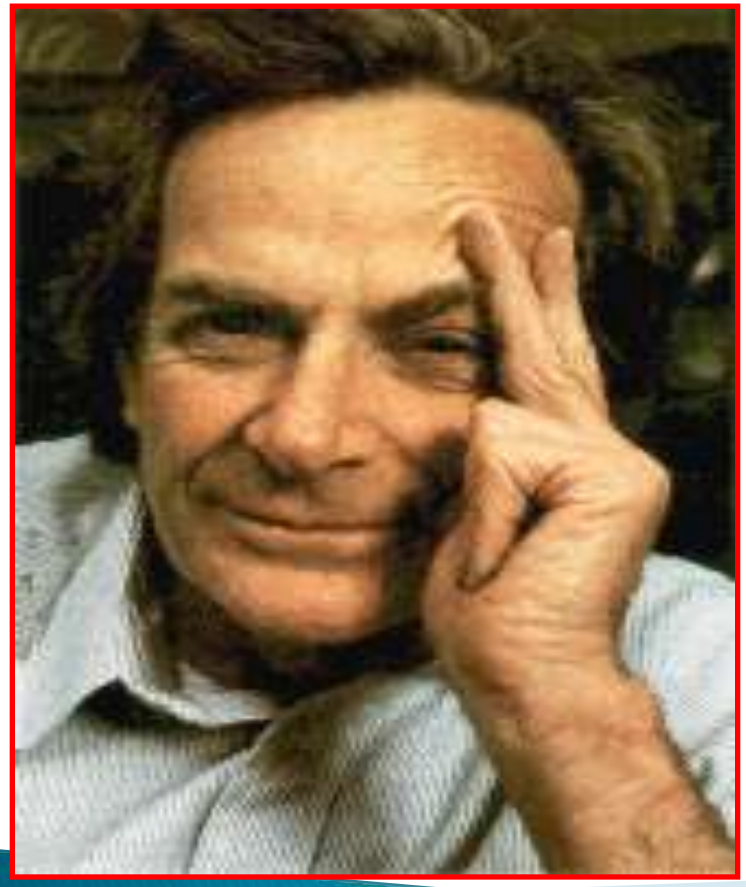
can be squashed

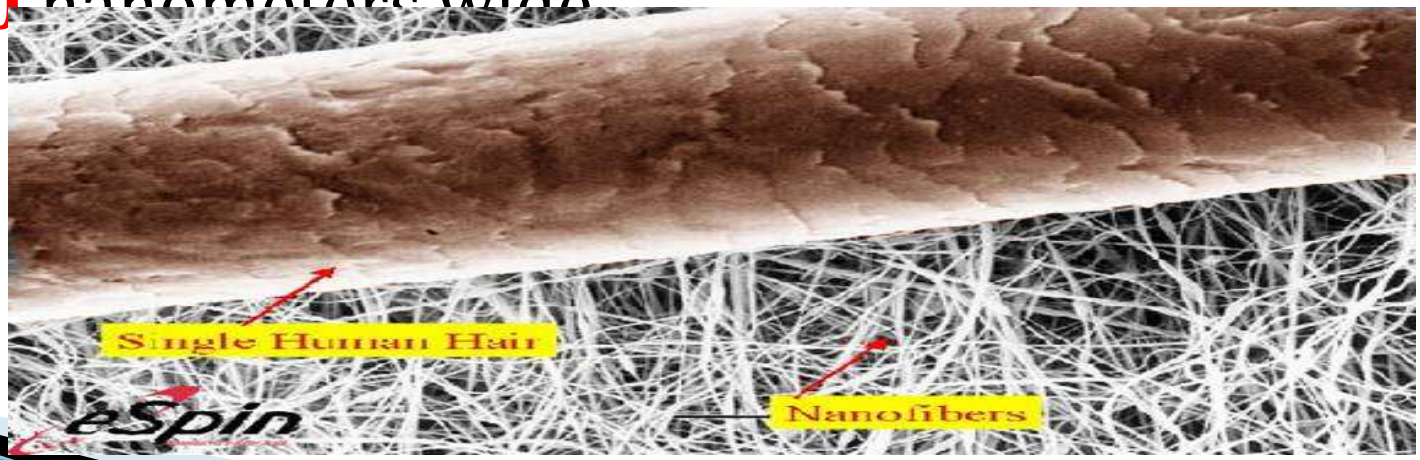
Nano Science



"There's Plenty of Room at the Bottom"
Richard Feynman (Caltech,1959)

What is "nano"?

- A nano is **one billionth** of a meter or **10^{-9} m**
- One nanometer is 10^{-9} meters or about 3 atoms long.
- For comparison, a human hair is about **60-80,000** nanometers wide.



Nano Materials

- Any materials that contains Particles, grains or clusters of the order of 1 to 100 nm or layers or filaments of that dimension are considered as Nano Materials.
- They have high surface-to-volume ratio.

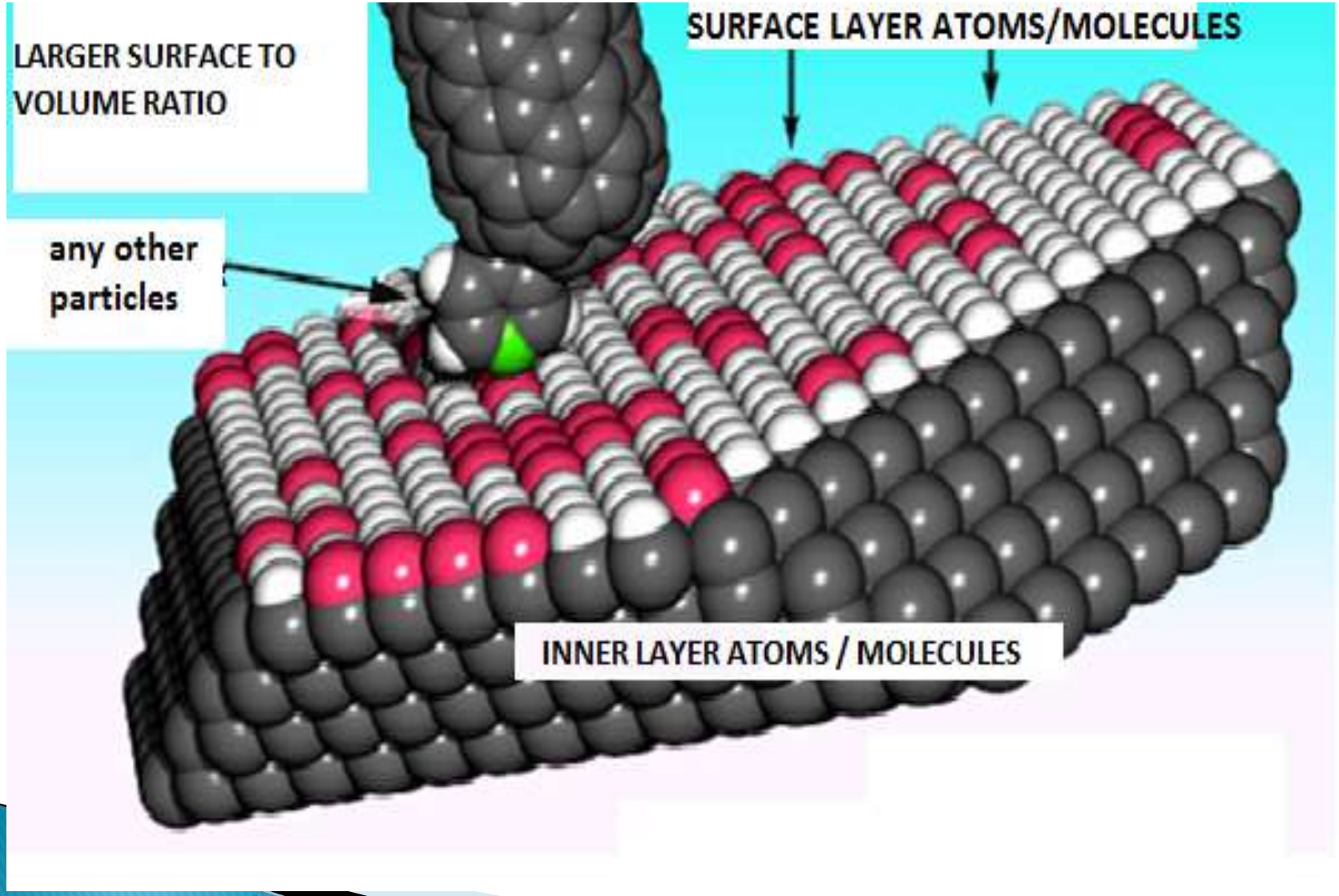
Nanotechnology

- A study deals with structures sized between 1 to 100 nanometer in at least one dimension, and involves developing or modifying materials or devices within that size is known as Nanotechnology.

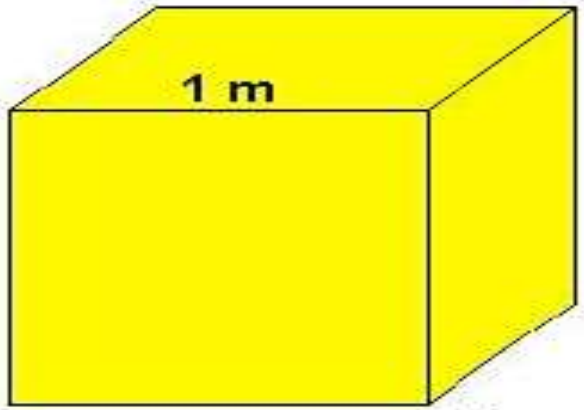
SIZE EFFECT

- At very small sizes the physical properties such as mechanical, magnetic, electric and optical of materials can ***enhanced*** and **high surface to volume ratio become increases**.

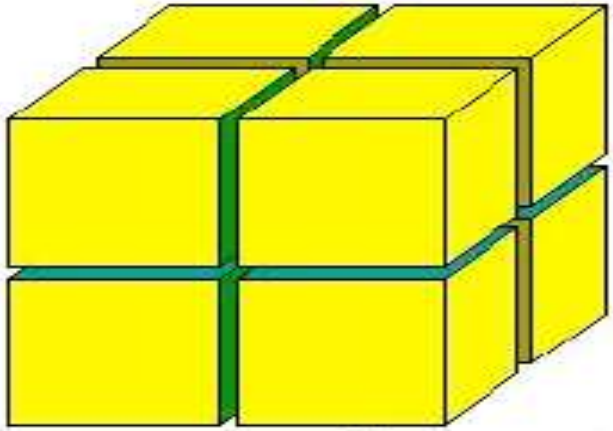
Why is Large Surface Area Important ?



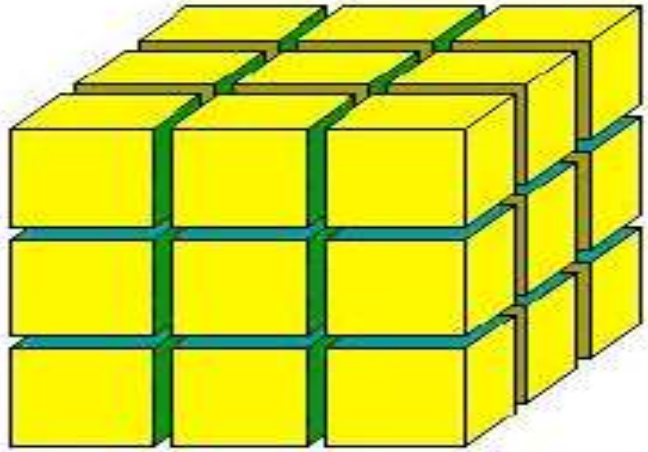
Role of Nanotechnology in Greater surface area



Area = 6 x $1m^2$ = 6 m^2



Area = 6 x $(1/2m)^2$ x 8 = 12 m^2



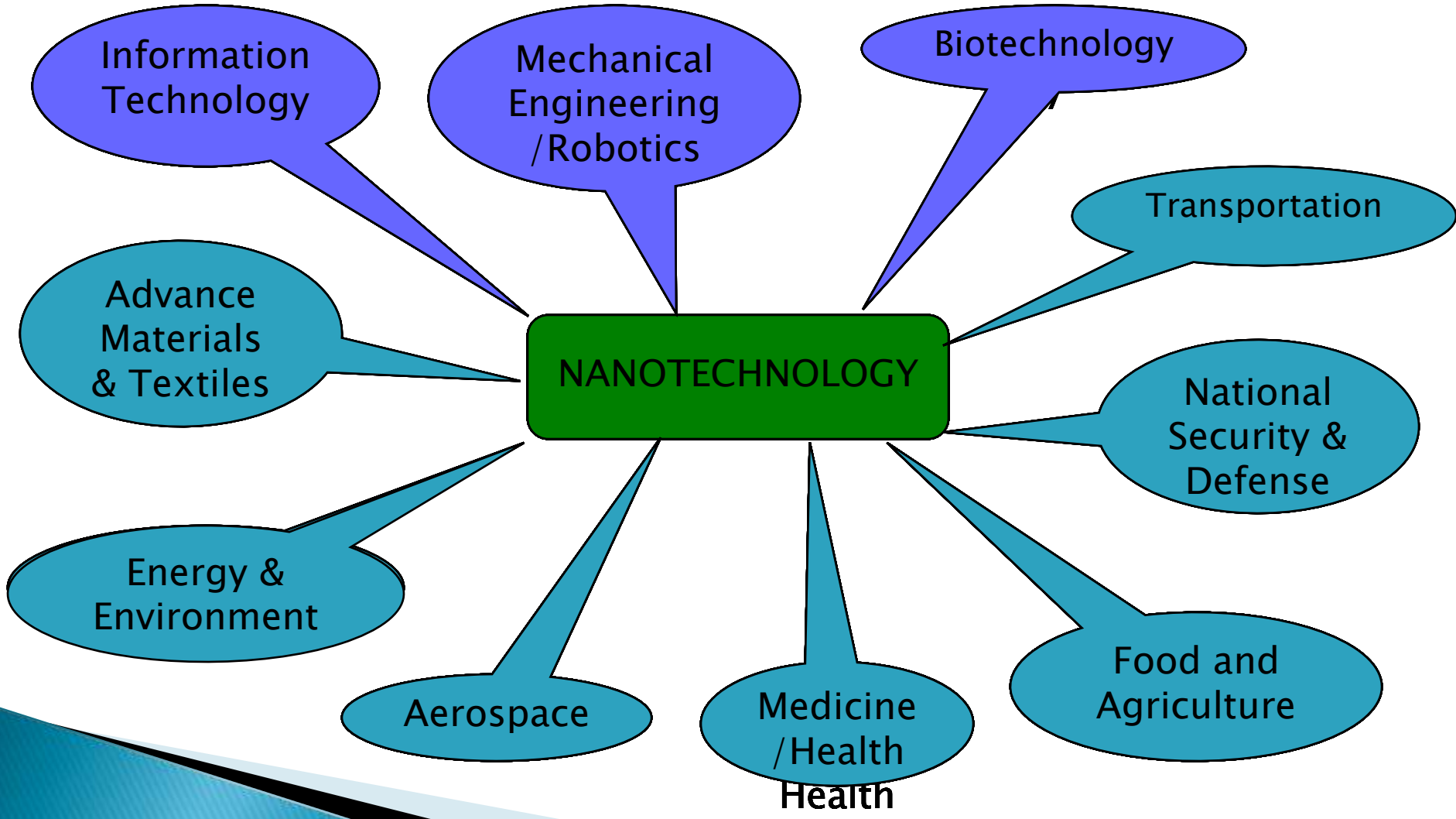
Area = 6 x $(1/3m)^2$ x 27=18 m^2

- **When atoms arranged on a surface such atoms are completely different from those buried in the bulk matter.**
- **If something has more surface area, there are more places for other chemicals to bind or react with it.**
- **These materials shows enhanced mechanical, magnetic, optical and chemical properties.**

Research areas in Nano

- **Nano particles or Nano Powders.**
- **Thin films (Nano layers).**
- **Carbon Nano Tubes.**

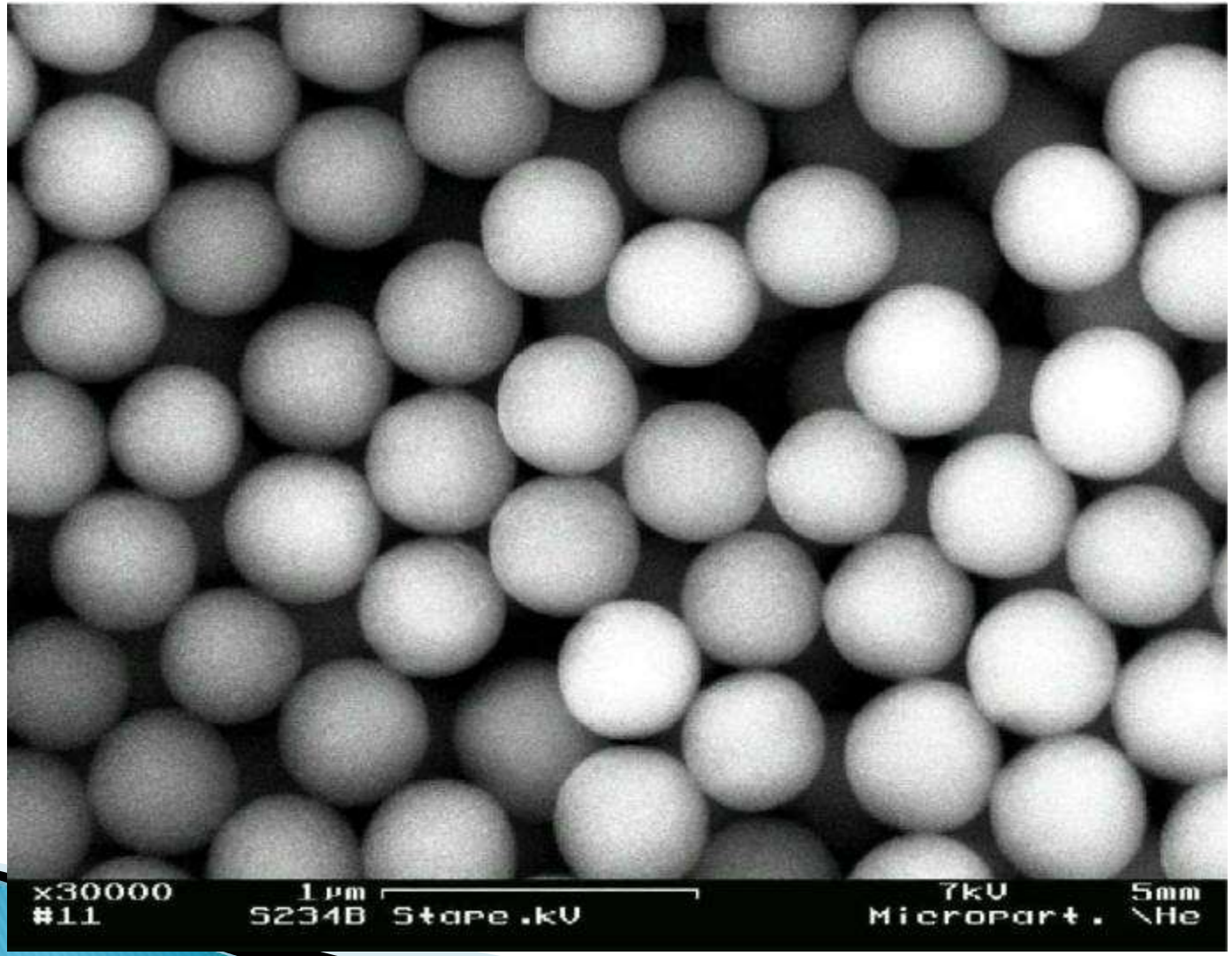
Nanotechnology spans many Areas



Current Research and Applications

Materials Science	Powders, Coatings, Carbon Nano-Materials, C-NanoFabrics
Energy	Solar Power and PhotoVoltaics, Hydrogen Fuel Cells, LED White Light
Medicine/Biotech	Genomics, Proteomics, Lab on a Chip, C-Nanotubes,BuckyBalls
Electronics	RAM, Q-Dots, Q-Bits
Devices	Lithography, Dip Pen Lithography, AFM, MEMS

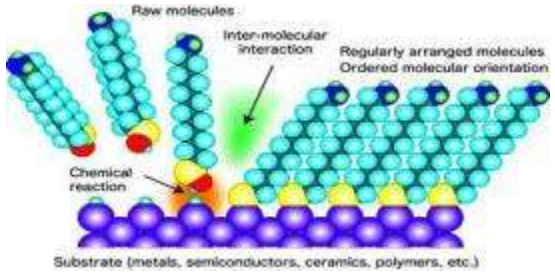
Nano Particles



Nano fabrication

- **Top-down nanofabrication** – start with large material and bring it down to the nanoscale

- **Bottom-up nanofabrication** – start with individual atoms and build upwards to make a nanostructure



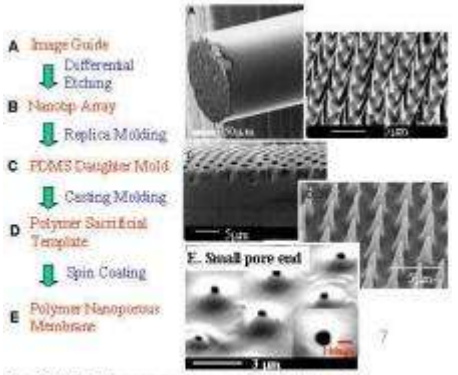


Fig. 3(i). DEL for nanoporous membrane fabrication

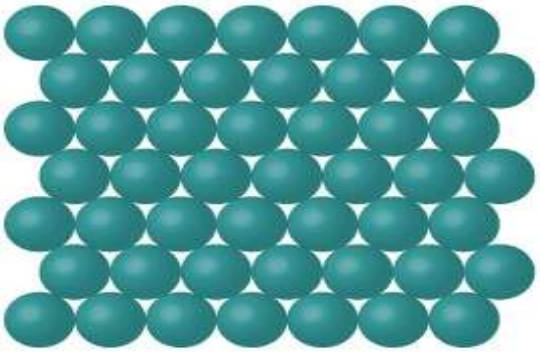
NANO materials

Nono crystals

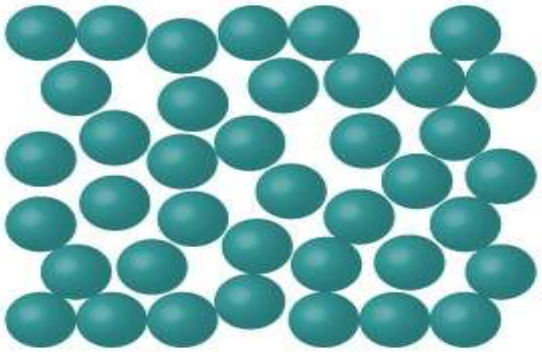
Crystalline nanoparticles are referred to as nanocrystals. In this materials the component atoms are arranged in a definite pattern (periodic arrangement).

Amorphous Nano materials

Atoms are arranged in irregular or non periodic pattern is known as amorphous



Crystalline



Amorphous

Applications of Nano Particles

- Metal 100 x's stronger than steel, 1/6 weight
- Catalysts that respond more quickly and to more agents
- Coatings that are nearly frictionless –(Shipping Industry)
- Materials that change color and transparency on demand.
- Materials that are self repairing, self cleaning, and never need repainting.
- Nanoscale powders that are five times as light as plastic but provide the same radiation protection as metal.

Thin films

- *A thin layer of materials created by condensation of atomic/molecular/ ionic species of matter one-by-one on a substrate.*

- *Thin films may be conductive, semi conductive & non conductive.*

- *Applied in micro-electronics, optical devices, communication, catalysis, mechanical coatings and energy generators.*

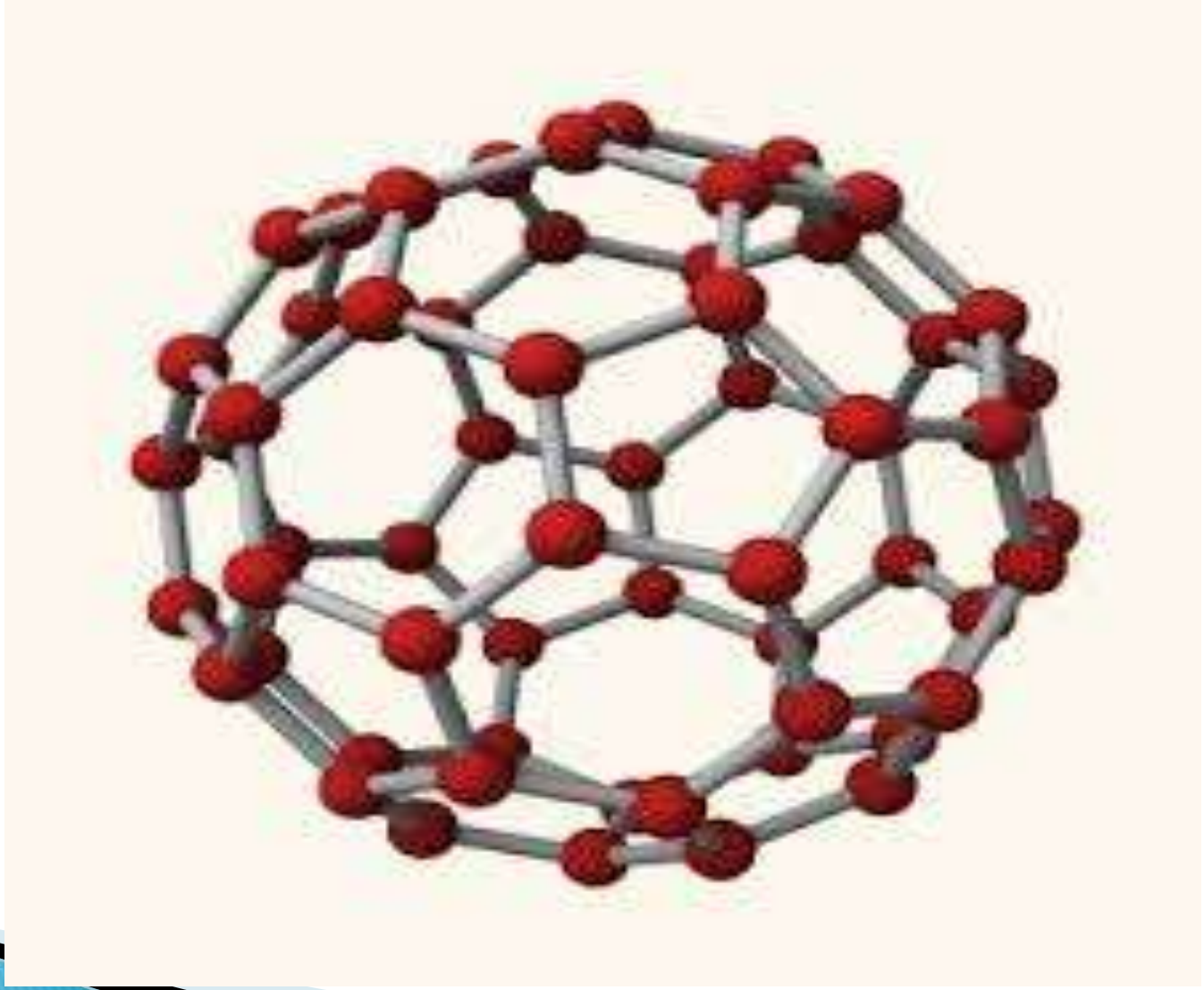
using Nanotechnology to coat objects.mp4

Preparation techniques

- *Thermal Evaporation*
- *Molecular Beam Epitaxy*
- *Sputtering*
- *Chemical Vapour Deposition (CVD)*
- *Spray pyrolysis*
- *Sol- gel*

CARBON NANO TUBES

BUCKYBALLS



- A buckyball is a molecule containing 60 carbon atoms.

The diameter is in the order of 1nm

BUCKYBALLS GROW UP TO BECOME NANO TUBES

BUCKYBALLS

- Production:

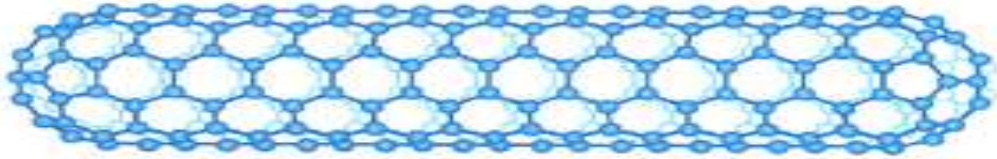
vaporizing carbon with laser and allowing the carbon atoms to condense.

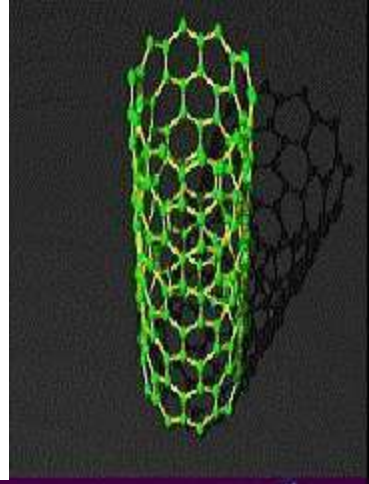
Applications:

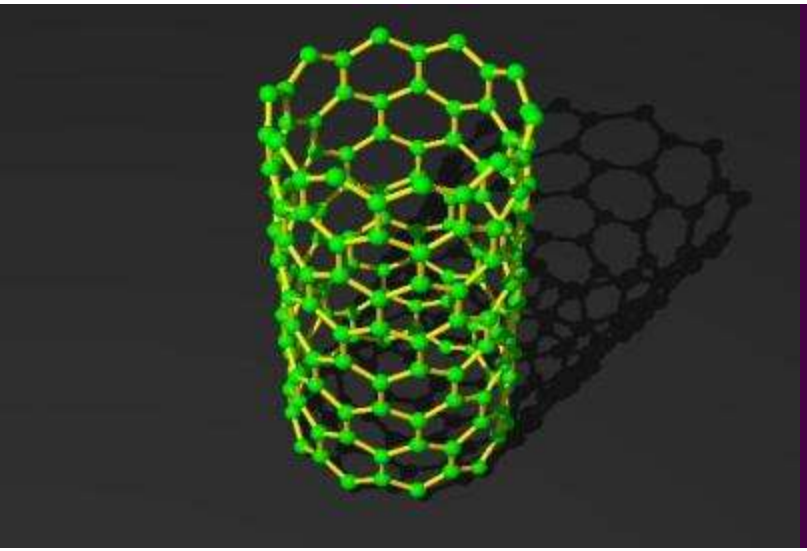
In medical field used as C60. Applied as antioxidants, counteracting free radicals in the human body.

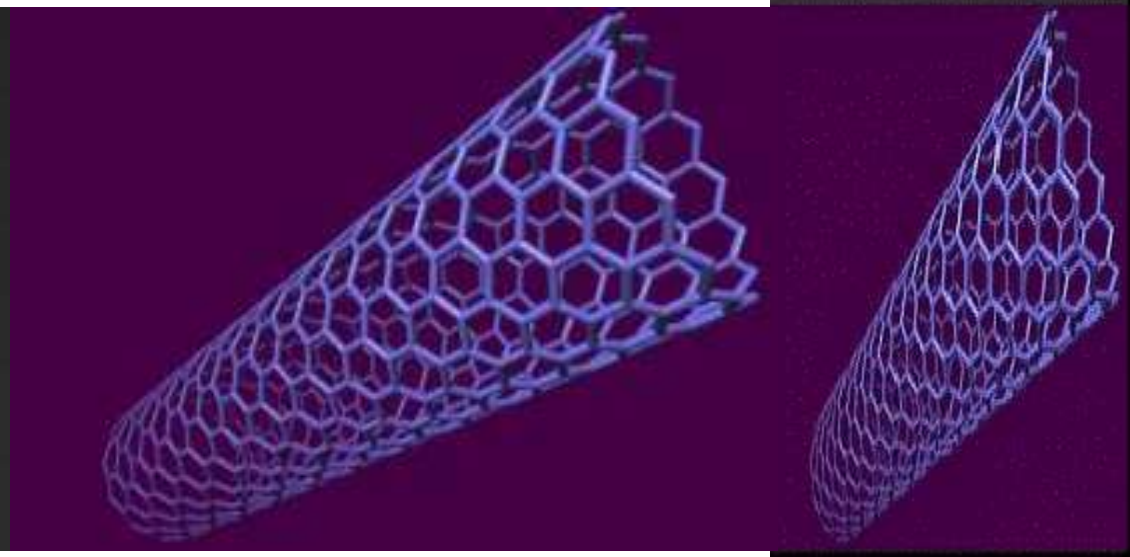
Buckyballs are more effective than normal antioxidants.

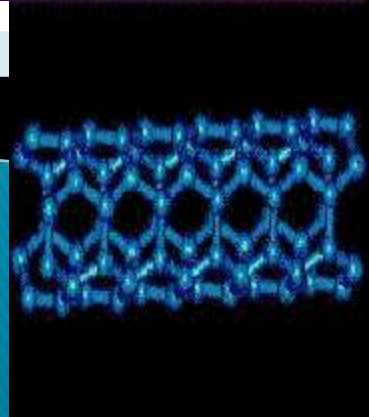
Because of large no of carbon atoms covalently bonded with free radicals.





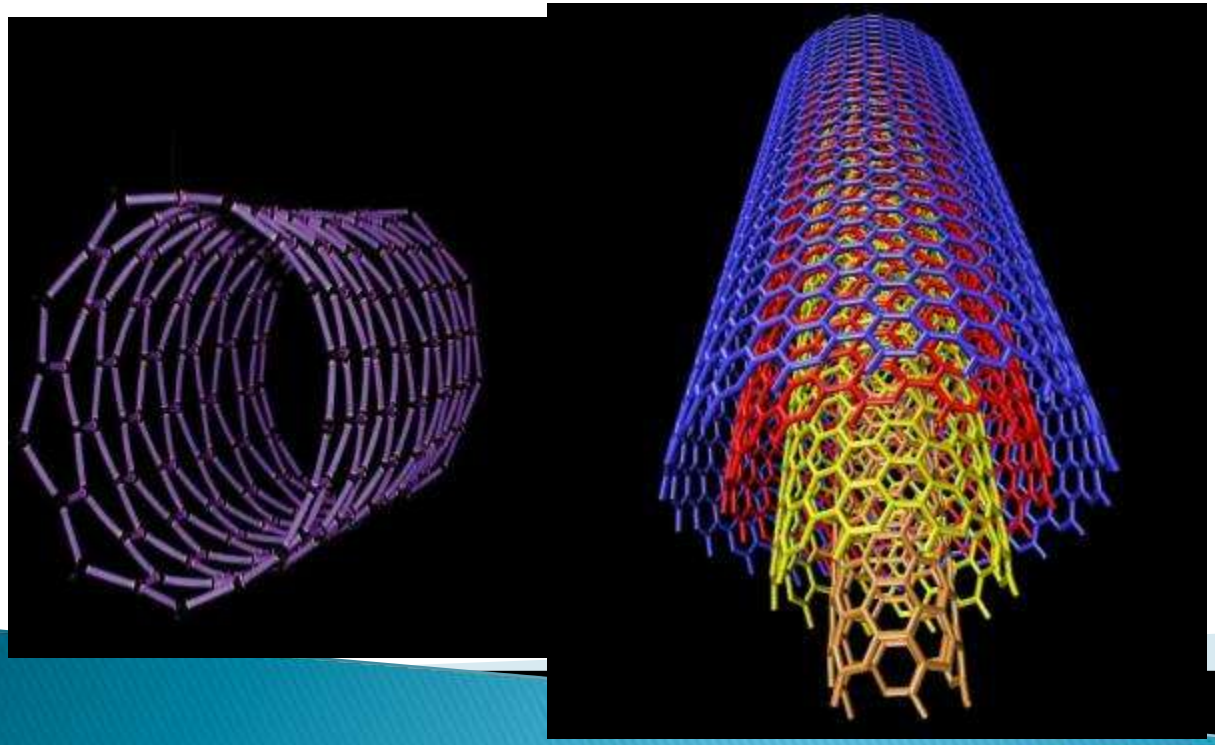






What are carbon nanotubes?

SINGLE WALLED & MULTIWALLED



- Carbon Nanotubes Basically BUCKYBALLS but the end never closes

- Nanotubes are tubular forms of carbon that can be envisaged as graphene sheets rolled into cylindrical form.

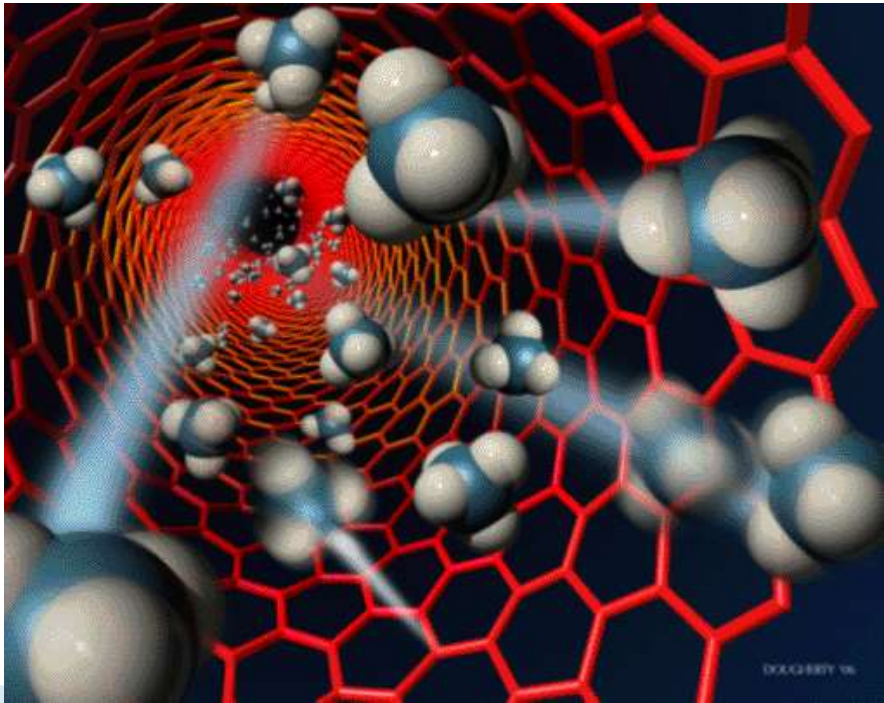
- Each nanotube is made up of a hexagonal network of covalently bonded carbon atoms.

Unique *Properties CNTs*

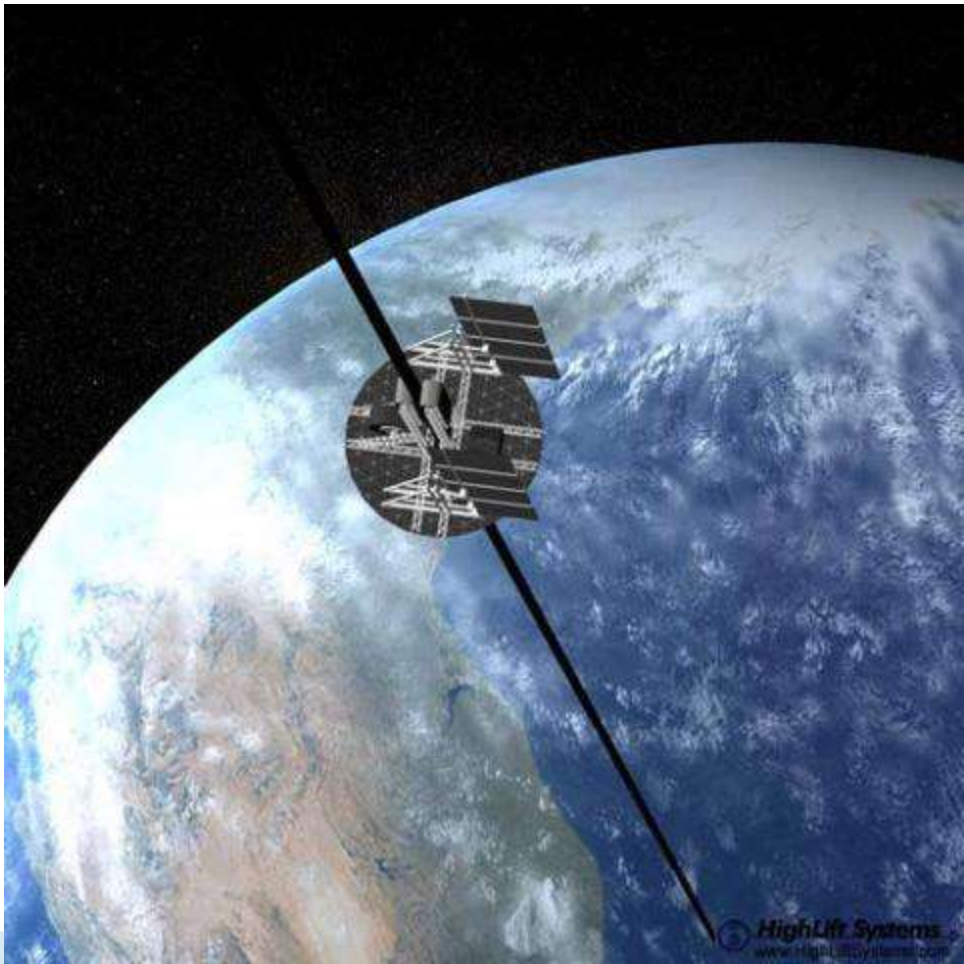
- **High Electrical Conductivity- current density of 4×10^9 A/cm^2**
- **highest modulus of elasticity (1 to 5 Tpa) ~18% elongation to failure**
- **Highly Flexible- can be bent considerably without damage**
- **Very Elastic High Thermal Conductivity**
- **Low Thermal Expansion Coefficient**
- **Good Field Emission of Electrons**
- **Highly Absorbent**
- **High Aspect Ratio (length = ~1000 x diameter)**

One-Dimensional Transport

- Due to their nanoscale dimensions, electron transport in carbon nanotubes will take place through quantum effects and will only propagate along the axis of the tube. Because of this special transport property, carbon nanotubes are frequently referred to as “one-dimensional.”



Nanotubes' excellent strength to weight ratio creates the potential to build an elevator to space.



THANKS