New College

B.Sc – IIIrd Year

Unit-4

Nano – Science & Nano-technology

1. Science is organised knowledge; where as technology is an application of knowledge to various system and subsystem.
2. It is the process of exploring new knowledge where as technology is the use of law of science to create a new Products

In single line Technology is the practical application of Science

Introduction

Nano science first captured the world's attention when nobal Prize winne Richard feynman delivered his famous 1959 speech

" There is Plenty of Room at the Bottom"

Richard feynman → California USA → Americal Physical Society Seminar

He asked couples of questions

(i) "Why we cannot write the entire 24 volumes of Encyclopedia Brittanica on the head of pin"

(ii) "I put out as a challanges; Is there no way to make the electron microscope more Powefull"

(iii) In this lecture he also asked building ciscuits having sizes few nanometers that can be used as elements in more Powerful Computers

His talks later Published in 1960 and it was the first introduction to "Nanotechnology". Though he never used the world Nanotechnology

The term "Nanotechnology" coined by Taniguchi (Tokyo Scierce University professor). in 1974, Taniguchi was associated with manufacturing materials with nanometer tolerences.

[1980–1986]↓

Scientist realized the importances of STM (Scanning tunneling Micoscope), fullerer etc, discoveries and declared that a new revolution is imminent with the term nanotechnology. Drexler developed and Popularized the Concept of Nanotechnology and founded the field of molecular nanotechnology. His vision of nanotecunology is ~~Obtain~~ often called "Molecular Nanotechnology" (MNT) or molecular manufacturing

Definitions of NaNoScience & NaNotechnology

Nano Science and technology deals with very small particles or Structure

The word "nano" has been derived from the Greek word "nano" that means "Dwarf" ↓ (a man with small height)

It refers to very small unit length measurment Corresponding to molecular scale.

$$1nm = 10^{-9}m$$

$$1nm = 0.000000001\,m$$

1nm is one Billonth of meter

Nano Science :- It is the study of those materials whose length lies in b/w the (1nm to 100nm)

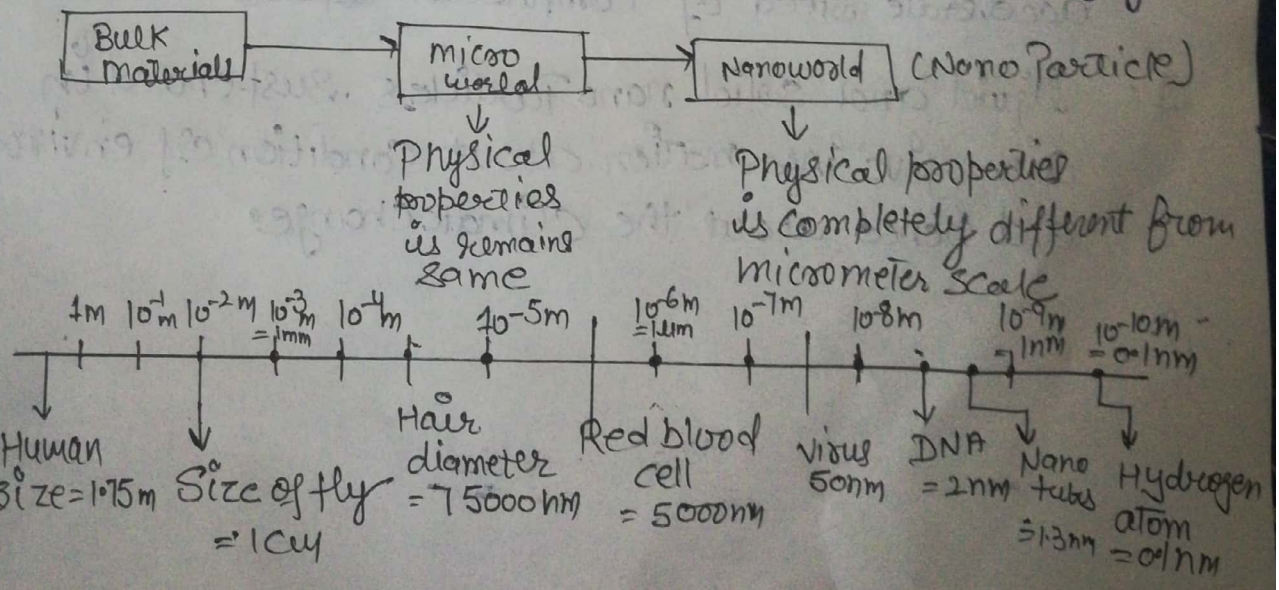
Nanotechnology :- It is a design, Production application of system devices and structures by controling shape and size at nano scale (1nm – 100nm)

Length Scale :-

① Nanotechnology is a process of miniturization from micrometer scale (10^{-6}m) to nanometer scale (10^{-9}m)
1nm is equivalent to 5 Si atom or 10 H-atom placed in a line

② When one goes down from bulk size (m/cm scale) micrometer scale, Physical properties of materials remains same. However is a nanometer scale (10^{-9}m) the physically properties of materials change drastically

If we move from macroscopic world to microscopic world the length scale also changed accordingly



Importance of Nano Scale

- Crystal in the nanometer scale have low melting point
- Crystal in the nanometer scale have reduced lattice Constants
- ferroelectrics and ferromagnetics may lose their ferroelectricity and ferromagnetism in nanometer scale.
- Bulk Semiconductors changes to insulators in the nanometer scale
- Energy levels of a metal changes when the number of atoms of the material is reduced
- Reactivity of bulk materials is different than the reactivity of same materials reduces to nanoscale

* Importance of Nano-technology ⇒

The multidisciplinary approach towards Nanoscience and Nanotechnology has revealed the Potential of nanomaterials and nanoscale engineering to Collect and Store energy reinforce materials, improve Solar cell technology, Sense Contaminants, enables life Saving drugs and Shrink size and at the same time accelerate Speed of Computation ~~Speed~~ devices.

1. liquid and solid nano Particles Suspended in air give information about Condition of environment and hence about the Climate change.

2.

Basic Reason for Novel properties of Nanostructure

1 Geometry of Molecules :-

Let's Compare two important isotopes of Carbon i.e diamond and graphite. The basic constituent of both graphite and diamond is carbon. But both of them show entirely different properties. Graphite is one of the softest substance where diamond is in the category of the hardest substance. Graphite is black in comparison of sparkling transparent diamond. Graphite is a good Conductor of electricity and diamond is Poor Conductor. So, one good reason for this different behaviour is difference in arrangment of carbon atoms in both the substances lies in different geometeries. The differences in properties are only because of the difference in arrangment of carbon atoms. This suggest that if we are able to arrange atoms and molecules, we are able to create anew substances with modified properties.

2. large Surface to Volume Ratio

The ratio of Surface atoms to interior atoms changes spectacularly if we keep on dividing successfully [Top down approach], a macro object into smaller parts

for example :-> A cube of iron of $1cm^3$, the percentage of Surface atom would be $10^{-5}\%$. when cube is divided into smaller cubes with an edge of 10nm, the percentage of Surface atoms would increases to 10%.

In cube of iron of $1nm^3$, every atom would be a Surface atom.

This dramatic increase in the ratio of Surface atoms to interior atoms in the nano-structures

and Nano-materials might explain why reduction to the size range of nanometers leads to great changes in the Physical and chemical properties of the materials.

3. Quantum Confinement effect

Semiconductors with all three dimensions in the 1-10nm size range are refered to as "quantum dots"

In this size range electrons exhibit quantum mechanical effects. The quantum effects such as quantization energy levels can be observed in principle and band gap energy 'Eg' becomes correlated with size; as the dimensions of the particle decreases, 'Eg' increases.

- Size-dependent properties are observed such as quantum confinement in semiconductor particles, and super-paramagnetism in magnetic materials etc.