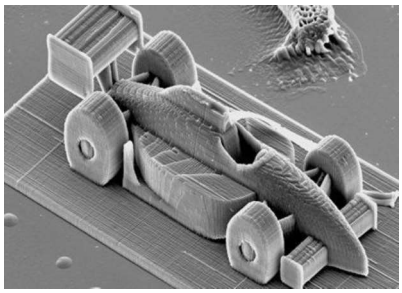
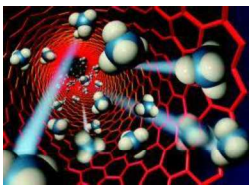
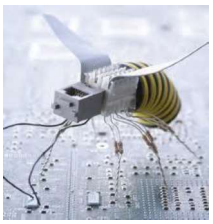
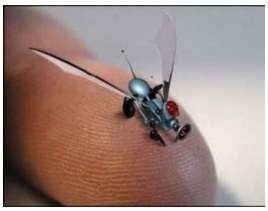
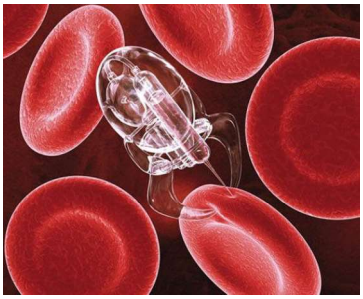
INTRODUCTION TO NANOMATERIALS

Dr Rajeshkumar Mohanraman
Assistant Professor Grade 1
School of Advanced Sciences
VIT Vellore

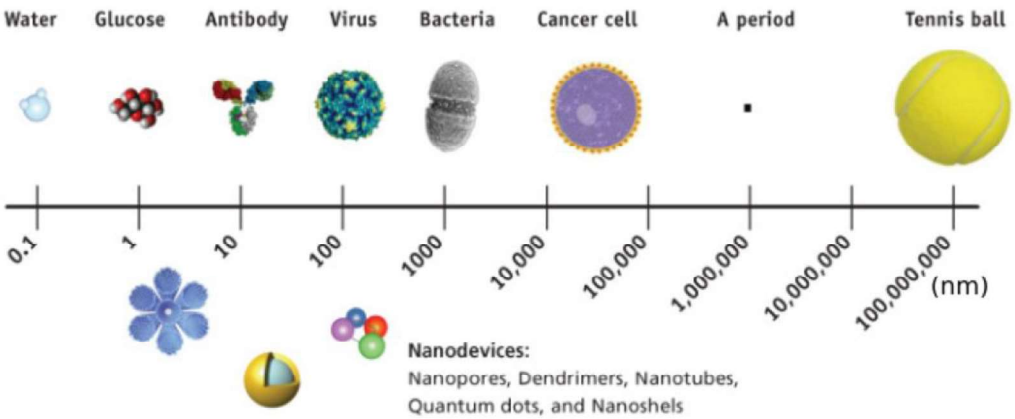
NANO TECHNOLOGY

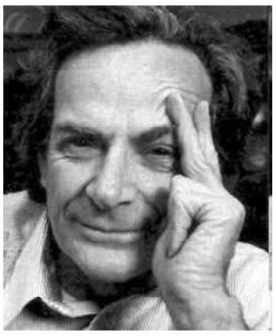
What is Nano?

- Nano refers to the scale of nanometers.
- A nanometer is one billionth of a meter
- This is the scale of molecules, proteins, and other nano-objects that are the topics of this course.
- The Nano-scale involves the range from approximately 100 nm to 1 nm.

Finger print of objects



ORIGIN OF NANOSCIENCE



Richard P. Feynman

"There is a plenty of room at the bottom"

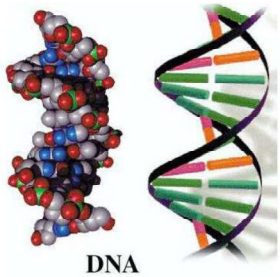
(Lecture in 1959 at the annual meeting of the American Physical Society)

Huge information can be stored at the tip of a ball pin. Molecules and atoms can be manipulated to store information

Professor Norio Taniguchi was the first person to use the term 'nanotechnology' in 1974.

"'Nano-technology' mainly consists of the processing of, separation, consolidation, and deformation of materials by one atom or by one molecule."

Examples of Nano-scale Structures



DNA
~2.5 nm diameter

Carbon nanotube
~2 nm in diameter

Nano Science

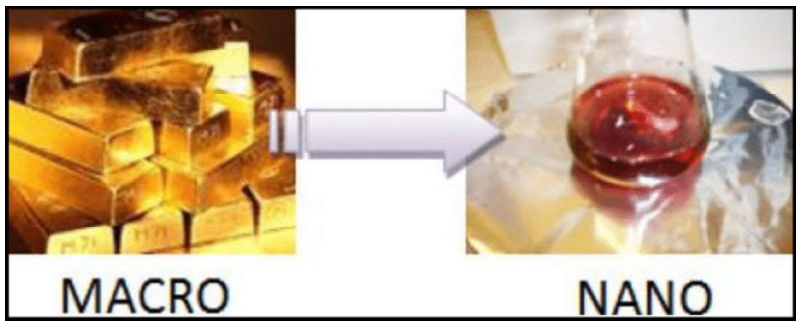
Nano Science can be defined as the study of phenomena and manipulation of materials at Atomic, Molecular and Macromolecular scales where properties differ significantly from those at a larger scale.

Nano Science is the study and understanding of properties of Nano Particles.

What is Nano-technology??

Nanotechnology can be defined as the design, characterization, production and application of structures devices and systems by controlling shape and size at a Nano meter Scale.

Professor Norio Taniguchi was the first person to use the term 'nanotechnology' in 1974.



What is Nano material??

Nano Materials could be defined as the materials with at least one of its dimensions in the range of 1-100 nm.

Why are nanomaterials so special?

The properties of Nano Materials are very much different from those at a larger scale.

Physical properties change due to :

1. Large Surface Area to Volume Ratio
(a) large fraction of surface atoms
(b) large surface energy
2. Quantum Confinement

These factors can charge or enhance properties such as reactivity, strength and electrical characteristics.

Increase in surface area to volume ratio:

The ratio of surface area to volume ratio is large for nano materials.

Example1:To understand this let us consider a spherical material of radius'r'. Then its surface area to volume ratio is 3/r. Due to decrease of r, the ratio increases predominantly.

Spherical material

For a sphere of radius '*r*', we have

$$\frac{\text{Surface area of the sphere}}{\text{Volume of the sphere}} = \frac{4\pi r^2}{(4/3)\pi r^3} = \frac{3}{r}$$

. This shows that by reducing the size (or radius) of a spherical object, the spherical area to volume ratio increases.

Does Size Play Big Role??

Surface to volume ratio ??

1 cm	2 cm	3 cm
SA = 6 cm²	SA = 24 cm²	SA = 54 cm²
Vol = 1 cm³	Vol = 8 cm³	Vol = 27 cm³
SA:Vol = 6:1	SA:Vol = 3:1	SA:Vol = 2:1

Quantum Confinement

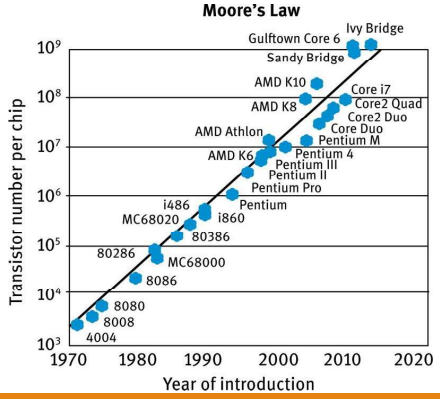
In Nano Crystals, the Electronic energy levels are not continuous as in the bulk but are discrete (finite density of states), because of the confinement of the electronic wave function to the physical dimensions of the particles. This phenomenon is called Quantum confinement and therefore Nano Crystals are also referred to as quantum dots (QDs).

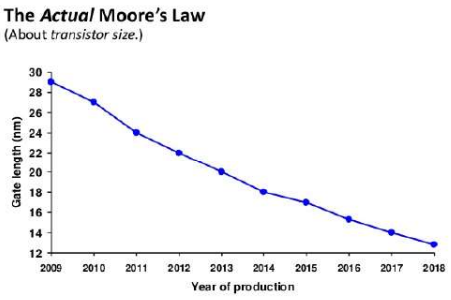
Moore's law

Mr. Gordon Moore observed that the size of transistor reduces linearly over a time. It is empirical law.

Definition

The no. of transistors on a specific area (cm^{-2}) of an IC (integrated circuit) doubles every 18 months. Or the size of transistor on an IC shrinks almost to half for every 18 months.

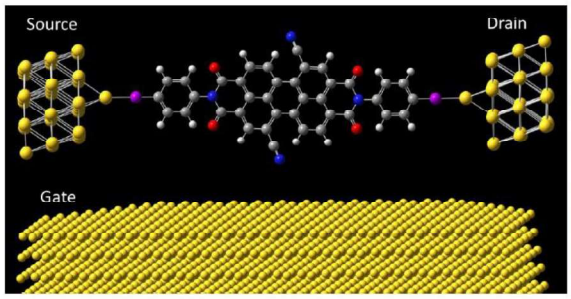




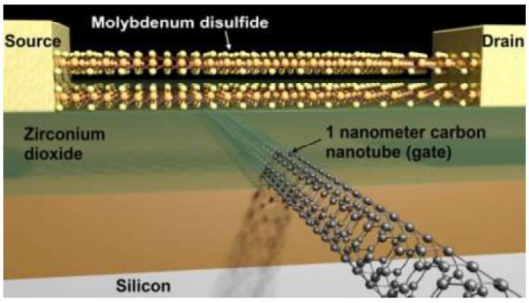
Deviation from Moore's law

Now, the size of a transistor reaches close to critical dimensions and hence Moore's law may deviates from linear behavior.

Smaller Transistors on the way....



Molecular Transistor



Nanotube as gate material