Nano Technology

Nano Scale

- Nano scale is the size at which nano - technology operates.
- The Prefix nano is derived from a greek word nanos which means a very short man or dwarf.
- Name is used in scientific units to denote one-billionth (10^{-9}) of the base unit.
- Nano scale = 1nm to 100nm.
- A well accepted convention is that for something to exist on the nano scale, atleast 1 of its dimensions (L,B,H) must be in the range of 1nm to 100nm. This scale is smaller than the size of bacteria (10^{-6})or virus (100nm).

What is so special about nano scale?

- Material may exhibit significantly different properties and behaviour at nano-scale than what they show at macro/bulk scale.
- There may be a change in physical properties, chemical properties, magnetic properties, optical properties, electrical & heat conductivity etc.

Nano Technology

Some Examples

Gold

- It is a solid yellow metal, non-reactive at the macro scale. But at the nano scale, it becomes liquid.
- It shows different colours like red, yellow and purple depending upon the size it also becomes chemically very reactive.
- So, it can act like a catalyst.

Silver

- At nano scale silver also exhibits different colours i.e. blue, yellow, red depending upon size.
- There is also a change in biological properties as silver becomes bactericidal.

Copper

- At nano scale, it becomes transparent.

Nano Technology

Carbon

Graphene

- One atom thick honey-comb lattice of carbon atoms.
- It is a considered as the new wonder material because of its impressive collection of superlative properties.
- It was discovered in 2004 and the scientists won 2010 Nobel Prize in physics.

Properties

- It is harder than Diamond yet more elastic than rubber.
- It is tougher than steel yet lighter than aluminium.
- It is the strongest Known material (more than 100 times stronger than steel)
- It conducts heat 2 times better than diamond
- Its electrical conductivity is 13 times better than copper and sliver.
- It is impervious so that even Helium cannot pass through it.
- It has very high surface area.
- It is almost transparent.

Nano Technology

- It has very high tensile strength i.e. it can be stretched upto 20% without breaking.

Carbon Nano Tubes(CNT)

- CNT are cylindrical molecules that consist of rolled up sheets of single layer graphene sheet.
- Its properties are similar to that of graphene.

Fullerene(C-60)

- These are spherical molecules about 1nm in diameter comprising 60 carbon atoms arranged as 20 hexagons and 12 pentagons like a football.
- C-60 was named Buckminster fullerene in recognition of the architect Buckminster fuller who was well known for building geodesic domes and the term fullerene was than given to any closed carbon caged.
- Several applications of this are:-
  - Miniature ball bearing to lubricate surfaces.
  - Drug delivery vehicles.
  - Electronics Circuits.

Nano Technology

Quantum Dots (QDs)

- These are nano scale semi-conductor particles due to nano scale, their optical and electronic properties differ from those of large particles.
- Quantum dots emits lights of specific frequency if electricity or light is applied to them and these frequency can be precisely tuned by changing the dots size, shape and material giving use to many applications.
- Larger QDs emit longer wavelength like orange & red.
- Shorter QDs emit shorter wavelength like blue and green.
- QDs have wide applications in display technology like TVS, phones, laptops etc.

Nano Technology

Why do materials behave differently at nano scale?

- Vastly increased surface area to volume ratio at the nano scale. Thus, as particle size decreases, a greater portion of the atoms are found at the surface compared to those inside. Thus, all the surface related phenomenon become more pronounced at the nano-scale.
- For Example: Nano particles may become chemically more reactive as chemical reactions occur at the surface
- Quantum Mechanics plays a dominant role at nanoscale and classical laws of physics plays a very negligible role.
- At macro scale, we see that forces like gravity, friction, etc. plays a very dominant role in dictating the behaviour of materials but at Nano scale, other forces become more dominant like electromagnetic force. Thus, we can say that the game of science has different rules when you play it at nanoscale

Nano Technology

Nano Technology

- It refers to the technology which enables us to see, understand and manipulate the matter at nano scale.
- It enables us to exploit the novel properties at nano scale.
- It is not just one science or one technology, it is a platform that includes physics, chemistry, biology, electronics, medicines, etc.
- Thus, it is an inter-disciplinary field of study.

Historical Background of Nano Technology

- 1959: Richard Fynman gave a lecture on "There is plenty of room at bottom"
- 1974: Norio Taniguchi coined the term Nano Technology
- Dr Eric Drexler wrote a book "Engines of Creation: The Coming Era of Nano Technology"
- 1991: One of the landmark discovery in nano technology was discovery of carbon nanotubes by Sumio Jijimi
- 2004: Another landmark discovery was the discovery of Graphene by Andre Geim and Novoselo for which they were awarded 2010 Nobel Prize in Physics

Nano Technology

Applications of Nano Technology

Medicines

- Targetted Drug Delivery
  - Nano Technology helps in targetted drug delivery of drugs like anti-cancer drugs precisely to the cancer cells or infected cells using nano particles as drug cancer.
  - Benefits:
    - Bio Avaialability of drugs improves
    - Healthy cells are not damaged

- Targetted Heat Therapy
  - Gold Nano Particles are targetted to bind to cancer cells by attaching anti-bodies to the nano gold surface.
  - Then, irradiating the area of tumour with infrared lasers which passes through the body flesh without heating it.
  - But gold nano-particles is heated significantly leading to the death of cancer cells

Nano Technology

- Medical Nano Robots
  - Nano sized robots will navigate inside the human body, transport important molecules, manipulate microscopic objects and communicate with the physician by way of miniature censors.
  - They will help in early detection of disease.
  - These medical nano robots can also be made to work like artificial RBCs and WBCs

- Diagnosis (Lab on a Chip)
  - Nano scale diagnostic device helps to perform multiple lab test on a single platform
  - It is very fast and require very small fluid volume.

Electronics

- Miniaturization: Use of CNTs, Graphene and other nano materials will help in further miniaturization in electronics.
- Field Emission Display: Carbon Nanotubes can be used as electron emitters with extremely high efficiency and very less energy consumption.

Nano Technology

- **Increase in Data Storage Capacity:** Due to high surface are to volume ratio, nano materials like Graphene and CNT will help in increasing data storage capacities many times.

Agriculture: Precision Farming

- With the help of nano sensors dispersed in the field and smart delivery systems, efficient use of resources like water, fertilizers, etc. can be done.
- Nano Sensors detect what the plant requires and delivery systems will deliver what the plant requires in optimum quantity.

Cosmetics

- Nano particles like Titanium Oxide and Zinc Oxide are used in the production of sunscreeens to protect against UV rays

Textiles

- Nano Fibres are being developed which will make the clothes water and stain repellant and wrinkle free.
- Nano Silver helps in keeping the harmful becateria away from the body as nano-silver is bactericidal.

Nano Technology

Energy Applications

- Hydrogen Fuel Cells: Carbon Nanotubes with larger surface area to volume ratio allows larger amount of hydrogen to be stored.
- Solar Cells: Indiam Salanide nano particles will drastically increase the conversion efficiency of solar energy into electrical energy.

Purification of Water

- Nano Particles of ferrous oxide are extremely effective in binding and removing arsenic from the ground water.
- Silver nano coating in water filters acts as bactericidal and thus, will kill the bacteria present in water.

Nano Technology

Concerns or Risks associated with Nano Technology

1. Health
    - Nano Particles can be easily inhaled.
    - They can pass from lungs into the bloodstream and other organs.
    - Once they are inside the body, it is not clear how long they remain inside or what they do
    - Current Science has no way of testing for nano waste in air and water and no way of cleaning up such pollution
2. Environment
    - Nano Particles can be harmful for other organisms in the environment.
    - For example- Silver Nano Particles which are used in Textile Industry or other areas cannot make a distinction between good bacteria and bad bacteria. When these silver nano particles are released into the atmosphere, they would also kill the beneficial bacteria which helps in decomposition of the waste organic matter.

Nano Technology

Concerns or Risks associated with Nano Technology

3. Privacy
    - With the help of nano technology, spying devices can become invisible to the naked eye and more mobile. It can, thus, invade our privacy.
4. Military
    - Untraceable weapons of mass destruction can be made with the help of nanotechnology.
    - Such threats will be hard to detect and counter
5. Nano Divide
    - It will create a divide between rich and poor as rich will be able to take advantage of advancements in nanotechnology