COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH
UNIVERSITY GRANTS COMMISSION

CHEMICAL SCIENCES CODE:01

4.1. Chemistry In Nanoscience And Technology

4.1.1. Microstructure: Microstructure is a structure of material at a length scale of ~10 to 1000 nm. Length scale is a characteristics length or range of dimensions over which we are describing the properties of a material or the phenomena occurring in materials. Microstructure typically includes such features as average grain size, grain size distribution, grain orientation and other features related to defects in materials.

A grain is a person of the material within which the arrangement of atom is nearly identical.

4.1.2. Macrostructure: It is the structure of a material at a macroscopic level where the length scale is ~ >1000 nm. Features that constitutes microstructure include porosity, surface coating, the such features as internal or external micro cracks.

4.1.3. Nanotechnology: This term is used to describe a set of technologies that are based on physical, chemical and biological phenomena earring at nanoscale.

4.1.4. Fullerenes and nanotubes, recently discovered, are the building blocks of a new class of ordered materials spherical fullerene C_{60} molecules can assemble in *fcc* crystal called **fullerites** and sigle-wall nanotubes can gather in ropes, the cross section of which makes an hexagonal lattice. These structures called nanocrystals different from ordinary crystals in many points.

4.1.5.

Level of structure	Example of technologies	Approximate length scale
Nanostructure	Nano-sized particles (- 5-10 nm) of Iron Oxide are used in ferrofluids or liquid magnets.	~ 10-9 to 10-7 m
Microstructure	The mechanical Strength of many metals and alloys depends very strongly on the grain size. The grain and grain boundaries in this accompanying micrograph of Steel are part of the micro-structural features of this crystalline material. In general, at room temperature a finer grain size leads to higher strength.	~>10-8 to 10-6 m
Microstructure	In automobiles to provide corrosion resistance.	~ 10-4 m
Atomic structure	Diamond is based on carbon- carbon covalent bonds. Materials with this type of bonding are expected to be relatively hard. Thin films of diamond are used for providing a wire resistant edge in cutting tools.	~ upto 10-10 m

Atomic arrangements long range order (LRO)	The ions in Lead-zirconium-titanate or PZT are arranged such that they exhibit tetragonal and rhombohedral crystal structures, the material is piezoelectric. PZT ceramics are used widely for many applications including gas Igniters, ultrasound generation and vibration control.	~ 10-10 to 10-9 m
Atomic arrangements short range order (SRO)	Ions in silica glass is only a short range order in which Si4+ and O2- ions are arranged in a particular way. This order however is not maintained over long distances, thus make silica glass amorphous. Amorphous silica classes based on silica and certain other form the basis for the entire fibre optical communications industry.	~ 10-10 to 10-9 m

4.1.6. Carbon nanotubes: There are many allotropes of carbon like cubic diamond, hexagonal diamond, graphite, fullerenes C60 and C70. In 1991, Ijima discover single wall carbon nanotubes (SWCNT's). Carbon nanotubes (CNT's) unique and fascinating structural, mechanical, electronic and chemical properties. They have applications such as pressure flow sensors nanoscale electronic devices, high strength composites, catalyst, light weight batteries and hydrogen storage devices.

4.1.7. Properties of nanomaterials:

- Nanotubes are really strong. Tensile strength is measured of the amount of force an object can withstand without tearing apart. The tensile strength of carbon nanotubes is hundred times greater than that of Steel of the same diameter. The materials have super hardness.
- Thermal properties such as melting point depend on size.

4.1.8. Quantum dot: Quantum dot are a new form of matter that can be considered as artificial atoms. They have linear discrete absorption spectra and photoluminescence that is tunable over a wide range from far infrared to deep ultraviolet.

4.1.9. Applications of nanomaterials:

Field/product	Applications	Examples	Features
Electrical devices	Ceramic capacitor	$BaTiO_3$	Small size, reduced power losses, enhanced capacitance values for a given component size.
Thermostats	Devices for thermal protection, current controlling devices.	ZnO	High sensitivity to temperature, low losses, smaller size
Magnetic devices	RAM, READ/WRITE heads, sensors	Cu-Fe alloys	High performance, improve sensitivity.
Inks, pastes, slurries	Screen printing, ink-jet printing, power impregnating, spin coating.	$BaTiO_3$, $SiCSnO_2$, $ZnOZrO_2$ ferrites	Dispersion in easily controlled, wide variation in viscosity can be accommodated.
Additives	Addition for powder coating of ceramic devices	$BaTiO_3$, ZnO	Reduction in processing time, cost and higher productivity

4.1.10. Quantum dot LEDs(QLED): This is made by quantum dots. It can emit at any visible or infrared wavelength. It can be fabricated into plastic, coatings, paint, filters and other forms, allowing them to be used almost anywhere.

4.1.11. Optoelectronics: It has broad photoluminescence (PL) tunability, high PL Quantum efficiency and enhanced nonlinear optical properties.

Its application include tunable IR-UV lasers and LEDs, display luminophores, optical electro modulation, memory storage, switches, optical limiting, DNA sites maekers and efficient sensors of explosive and toxic material.

4.1.12. Quantum information processing: It has enhance spin level splitting, single electron spin manipulation and very long spin coherence times.

It is used in spin transistors, nanosize magnets, Quantum computing and electron spin based memory.

4.1.13. Tougher and harder cutting tools: these are made of nanocrystalline materials such as tungsten carbide, tantalum carbide and titanium carbide. They are much harder, much more wear resistant, erosion resistant and last longer than their conventional counterparts. They also enable the manufacturer to machine various materials much faster. So they increases the productivity and significantly reduciing manufacturing cost. Hence they are useful for the miniaturization microelectronic circuits as micro drills.

4.1.14. High power magnets: The power of a magnet is measured in terms of coactivity and saturation magnetization values. The magnets made of nano-crystalline Yttrium-Samarium cobalt grains possess very unusual magnetic properties due to their extremely large surface area.

They are used in high power rare Earth magnets include quiter submarines, automobile alternators, land based power generators, motors for ship, ultrasensitive analytical instruments and magnetic resonance imaging (MRI) in medical diagnostics.

4.1.15. High sensitivity sensors:

- A carbon monoxide sensor made of zirconium oxide (zirconia) use sits chemical stability to detect the presence of carbon monoxide.
- High sensitivity sensors made out of nanocrystalline material are used in smoke detectors, ice detector on aircraft wings, automobile engine performance sensor.

4.1.16. Next generation computer chips: Nano-materials has the modern electronic industry break these barriers down by providing the manufacturers with nano-crystalline starting materials, ultra high purity materials, materials with better thermal conductivity, and long lasting durable interconnections.

4.1.17. Nano solar cells: When light hits an atom in semiconductors, those photos of light with lots of energy can push an electron out of its nice stable orbital around the atom. The electron is then free to move from atom, write the electrons in a piece of metal when it conducts electricity. Using nanosize bits abe semiconductors embedded in a conductive plastic maximize the chance that an electron can escape the nano-particle and reach the conductive plastic before it is trapped by other atom that has also been stripped of an electron. Once in the plastic, the electron can travel nappily through wire connecting the solar cell to the gadget like cell phone, laptop etc.