SYNTHESIS,CHRACTISATION AND APPLICATION OF NANOPARTICLES

M.Phil. Chemistry

(U.I.E.T)C.S.J.M.U, Kanpur

Supervision by-

(Dr. Birendra Pratap Singh)

University (Asst. Procter)

Represented by-

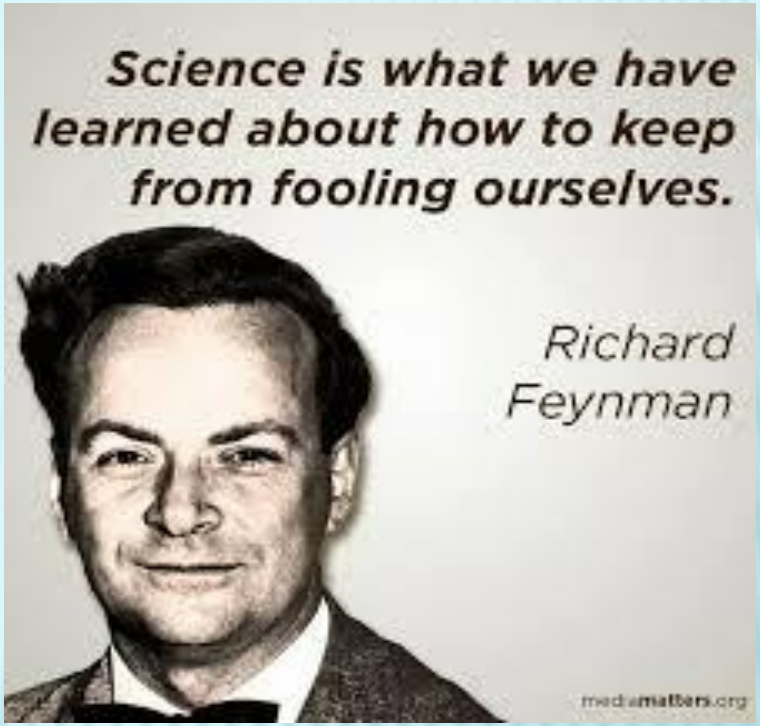
K.M.AMISH

HISTORICAL VIEW OF NANO SCIENCE

Professor Geoffrey Ozine of the University to Toronto is regarded as the father of Nanotechnology.

❖Many decades later in (1926) the first laboratory test proof on the size dependency of electronics properties of semiconductor had been published.

❖Richard Feynman predicted the potential application of atomic scale system in (1959) physicist Richard Feynman got Nobel Prize in (1960) in Nanotechnology



Professor Geoffrey Ozine of the University to Toronto is regarded as the father of Nanotechnology.

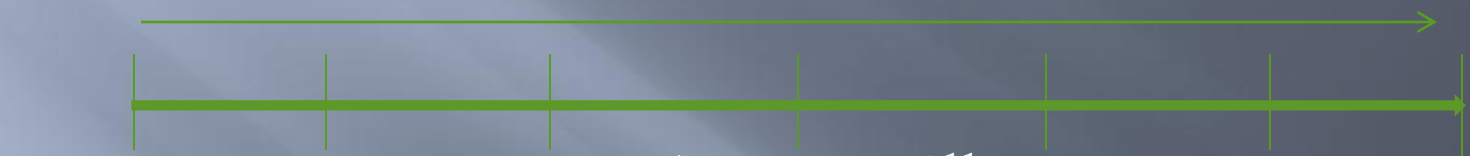
Richard Feynman predicted the potential application of atomic scale system in (1959) physicist Richard Feynman got Nobel Prize in (1960) in Nanotechnology.

INTODUCTION OF NANO SCIENCE

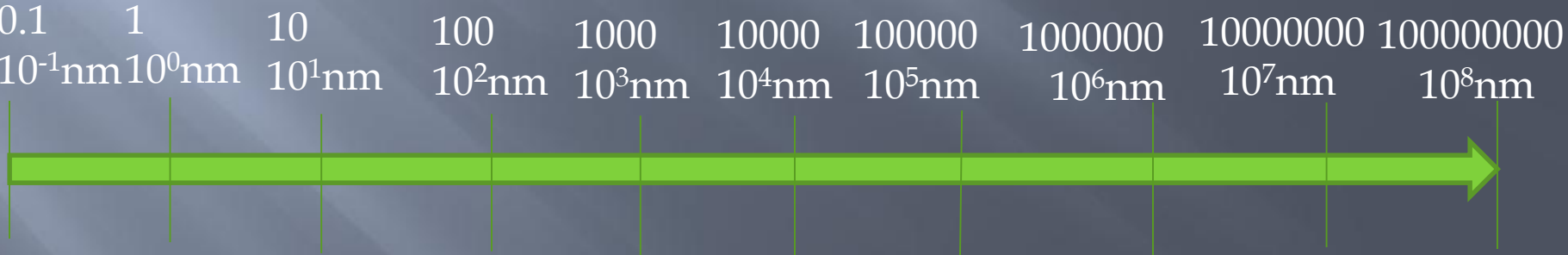
- Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales where properties differ significantly from those at larger scales.
- Nanoparticle is a fast developing field of research which as it the point of convergence of various disciplines.
- In recent Science Nanotechnology is a burning field for the researchers.
- Nanotechnology is an important field of modern research dealing with design synthesis and manipulation of particles structure ranging from approximately (1 – 100nm) in one dimension.
- A nanomaterials is an object that has at least one dimension in the nanometer scale (approximately 1 to 100nm)

Nano Scale Measurement

To increasing the meter size scale



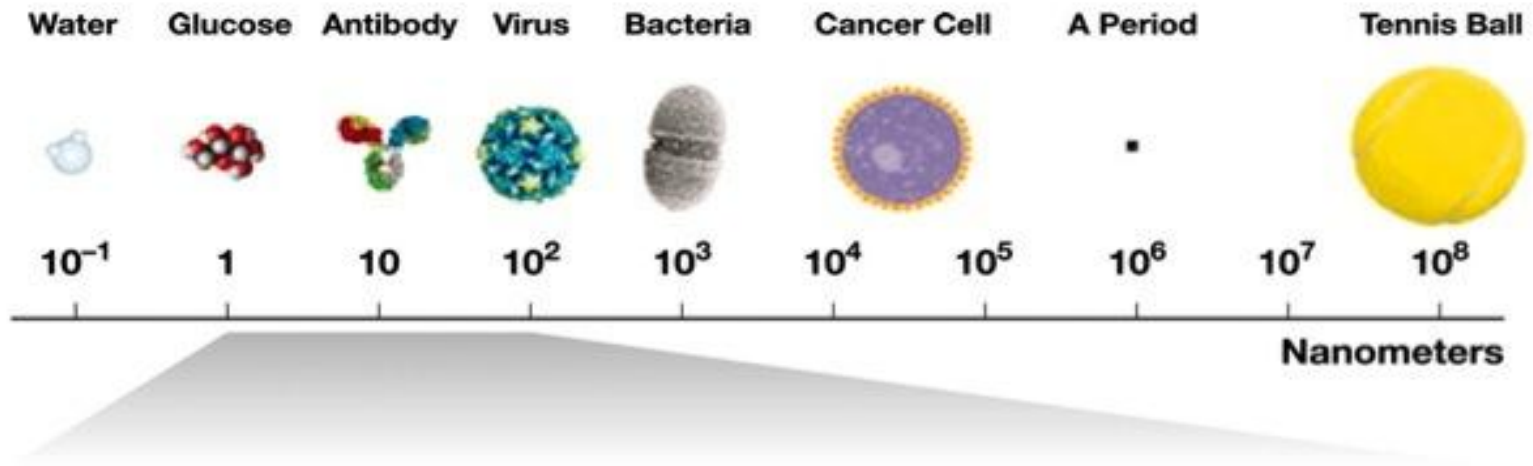
10^{-15}m	10^{-10}m	10^{-6}m	1 m	10^{11}m	10^{21}m	10^{27}m
Proton	Atom	Red blood cell	One half hand of human	The distance of the earth to the sun	Milky way	Observable Universe



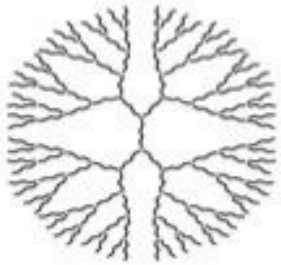
0.1 10^{-1}nm	1 10^{0}nm	10 10^{1}nm	100 10^{2}nm	1000 10^{3}nm	10000 10^{4}nm	100000 10^{5}nm	1000000 10^{6}nm	10000000 10^{7}nm	100000000 10^{8}nm
Molecule of water	Molecule of Glucose	Anti body	Virus	Bacteria	Human Hair Diameter	Resolution Unaided Eye	Pencil Tip	Ant	Tanis Ball

The size in Nanometer scales

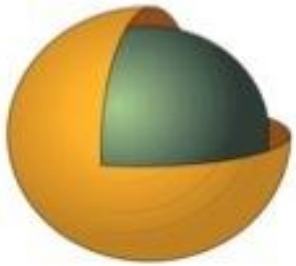
THE INCREASING NANOMETER SIZE SCALES



Liposome



Dendrimer

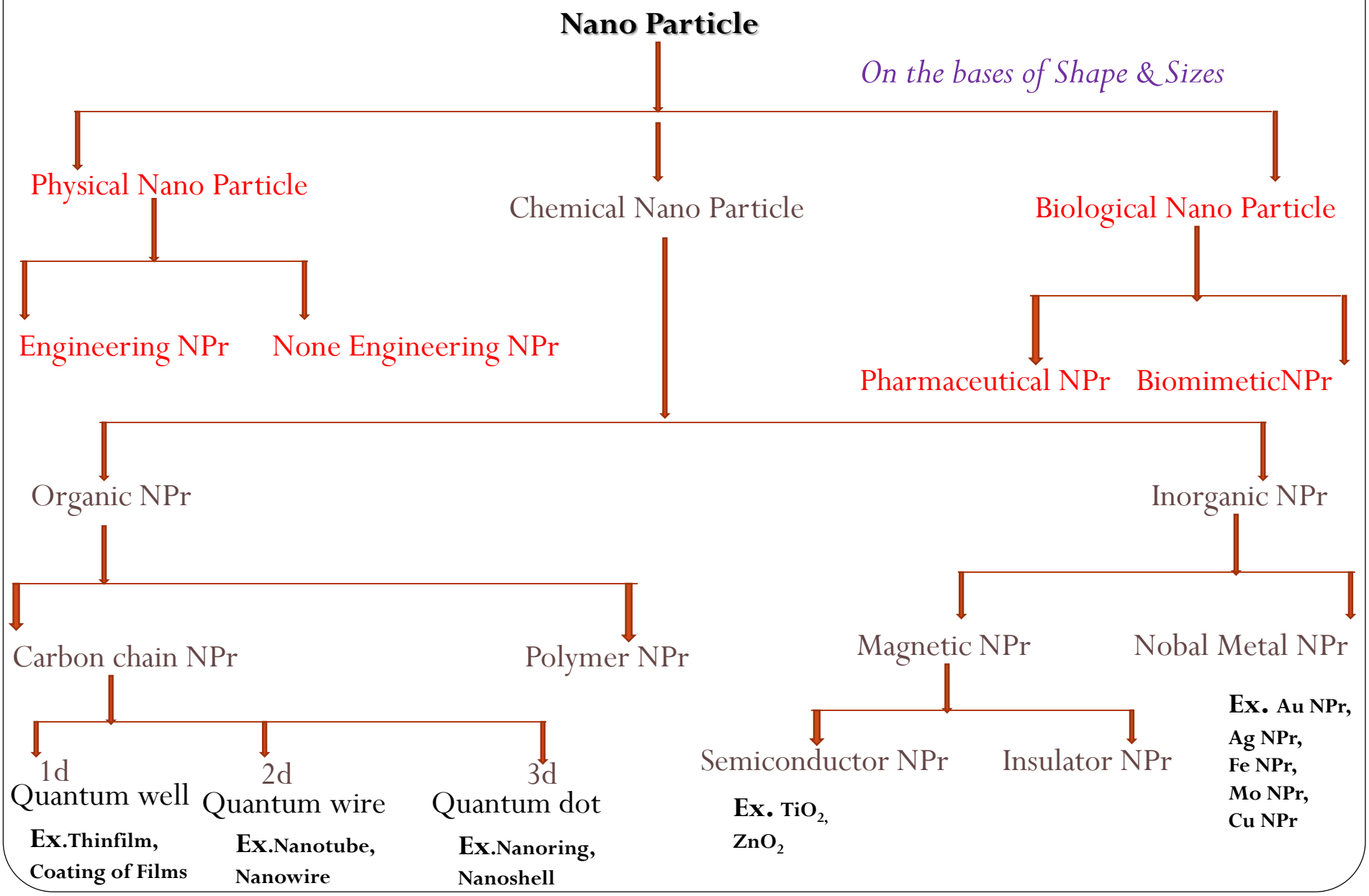


Gold Nanoshell

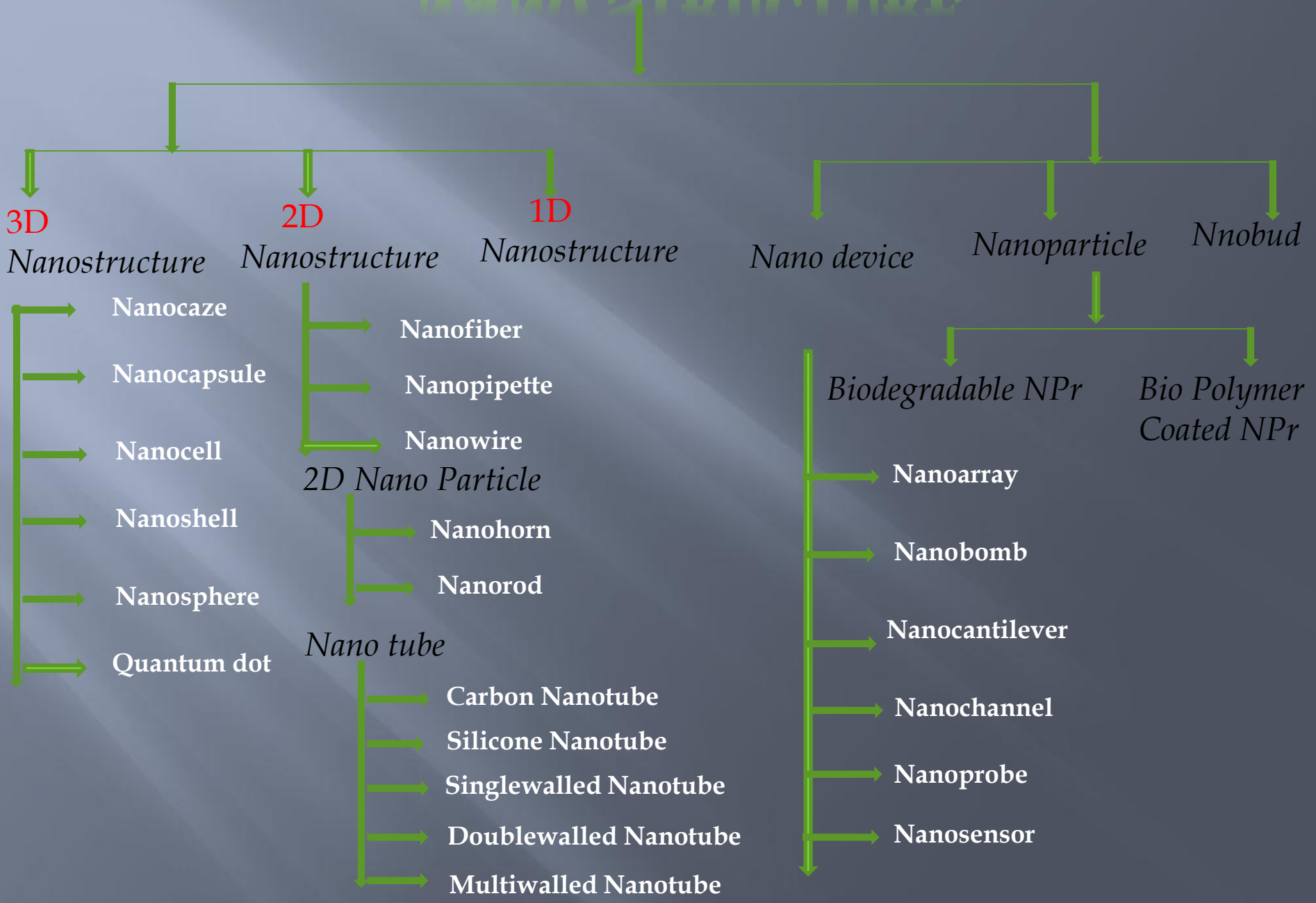
Quantum Dot

Fullerene

CLASSIFICATION OR TYPE OF NANOPARTICLE



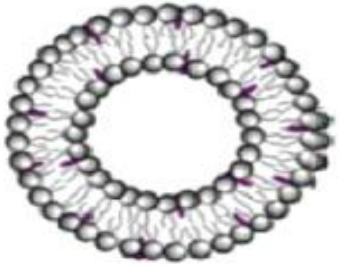
NANO STRUCTURE



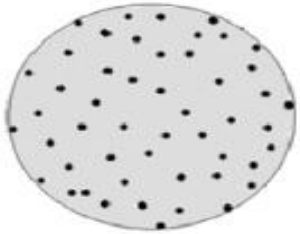
The different fields of Nanoparticls

Quantum Dots

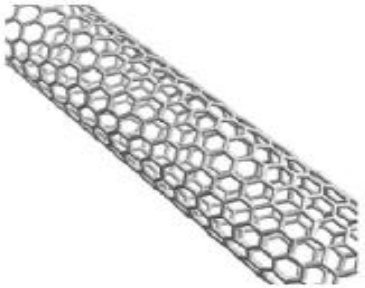
Liposomes



Iron oxide NPs

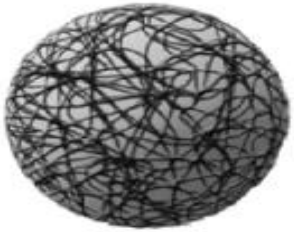


Carbon nanotubes

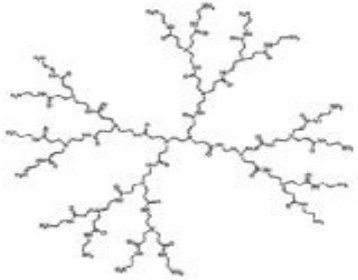


Gold NPs

Polymeric NPs



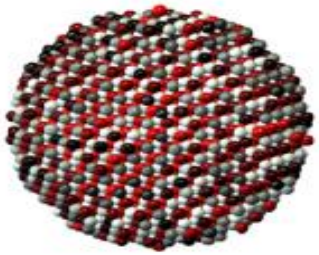
Dendrimers



Micro- and nanobubbles

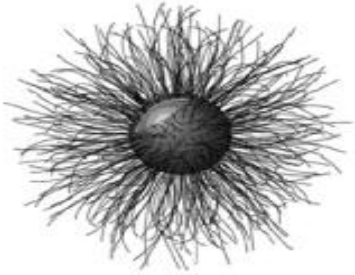
Upconverting NPs

Iron-platinum NPs



Nanoclusters

Functionalized NPs



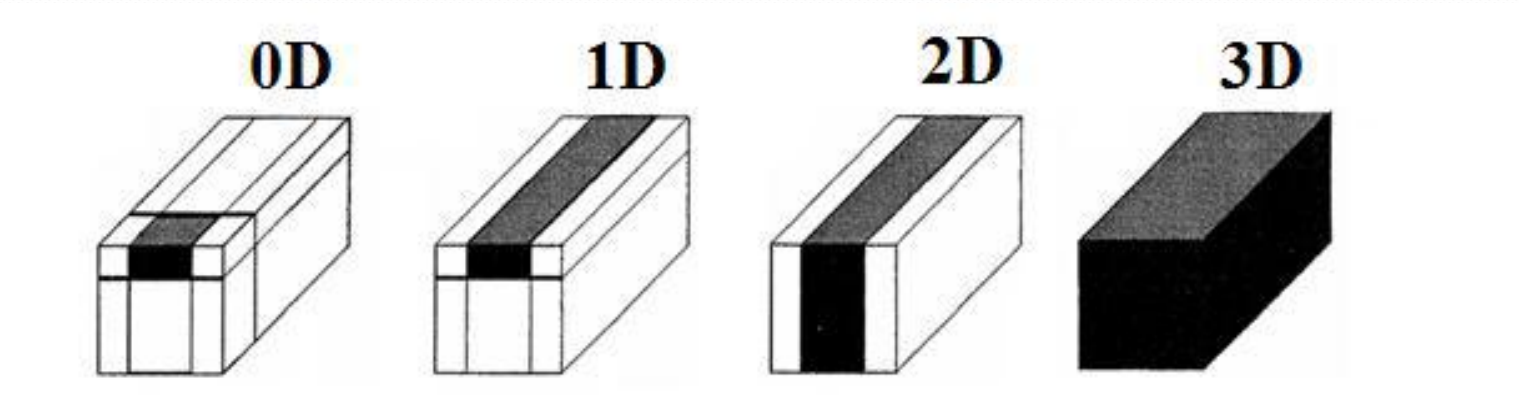
The different fields of Nanoparticles

Quantum dots.
Nanocluster.
Liposome's
Carbonnanotubes.
PolymerNPs.
Dendrimers.
Micro & Nanobubbles.
UpconvertingNPs.
Nanodevices.
Nanotransisters.
Nanocell.
Nanocapsules.
Nanoform,
Nanosphers.

Nanoribbons.
Nanopipette.
Nanobuds.
Nanowires.
Nanohorn.
Nanosprings.
Nanoneedles.
Nanoarry.
Nanobelts.
Nanopolymers.
Nanbomb.
Nanofluids.
Nanocomposits.
Nanocontilevers.

Nanoceramics.
Nanochannels.
Nanosensors.
Nanocages.
Nanobeams.
Nanobots.
Nanoshell.
Nanosim.
MetalNPs.
Nanomembranes.
Nanocrystals.
Nanofibers.
Nanoplates.
OxideNPs

Classification of Nanomaterials according to dimension



Dimension	Example of Nanomaterials
0D	Colloids, Nanoparticles, Nanodots, Nanoclsters
1D	Nanowires, Nanotubes, Nanobelts, Nanorods
2D	Quantum wells, Super lattices, Membranes
3D	Nanocomposite, Filamentry, Porous materials,

Synthesis of Nanoparticle

By Physical method:-

❖Physical method developed for synthesis of Nanoparticles often require special equipments or operation control.

❖ The physical method is also known as Top down approach which includes methods like diffusion, irradiation, thermal decomposition and discharge etc.

❖Physical method also include the routes i.e. Evaporation, Solvated metal atom deposition (SMAD), Laser ablation, Electrochemical discharge Method.

By Chemical Methods:-

❖Chemical method of synthesis of nanoparticles in detail which is most widely used techniques as for as antibacterial property is concerned .

❖Chemical method may be based on the kinetic control of nucleation and growth of the particle on electric stabilization in aqueous suspense.

❖Chemical precipitation method is often considerable economically viable for preparation of mono disperses metal oxide particles of different shapes and sizes.

❖Different other routes of chemical methods such as Sol – gel Techniques, Chemical precipitation, Hydrothermal, Micelles or micro emulsion, Electrochemical discharge, Polymerization, Gas – Phase Methods.

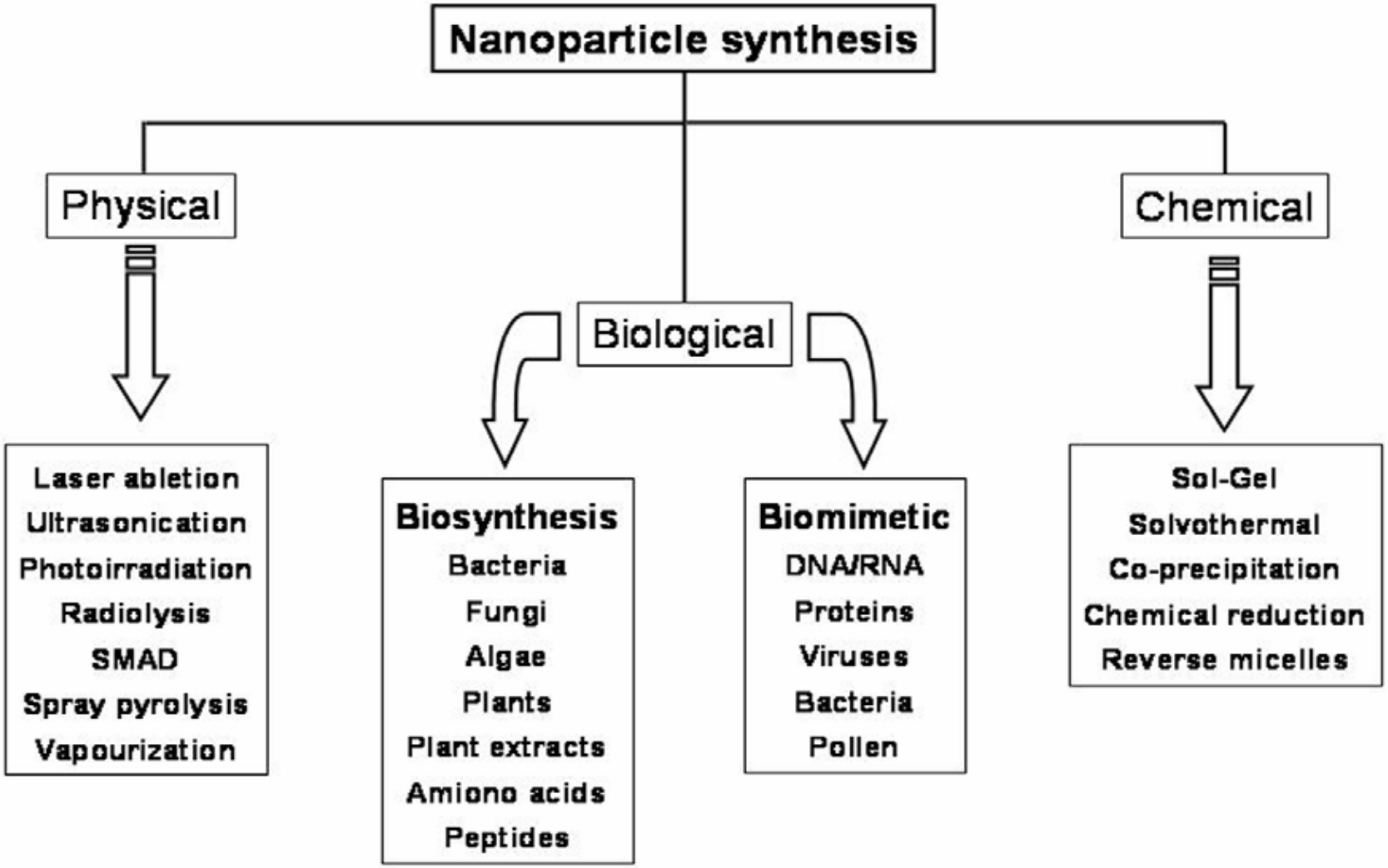
By Biological Methods:-

❖Green synthesis method is proved as beneficial over other methods ,that methods are ecofriendly approach and compatible for pharmaceutical and other biomedical application, as the toxic chemical are not used in these methods.

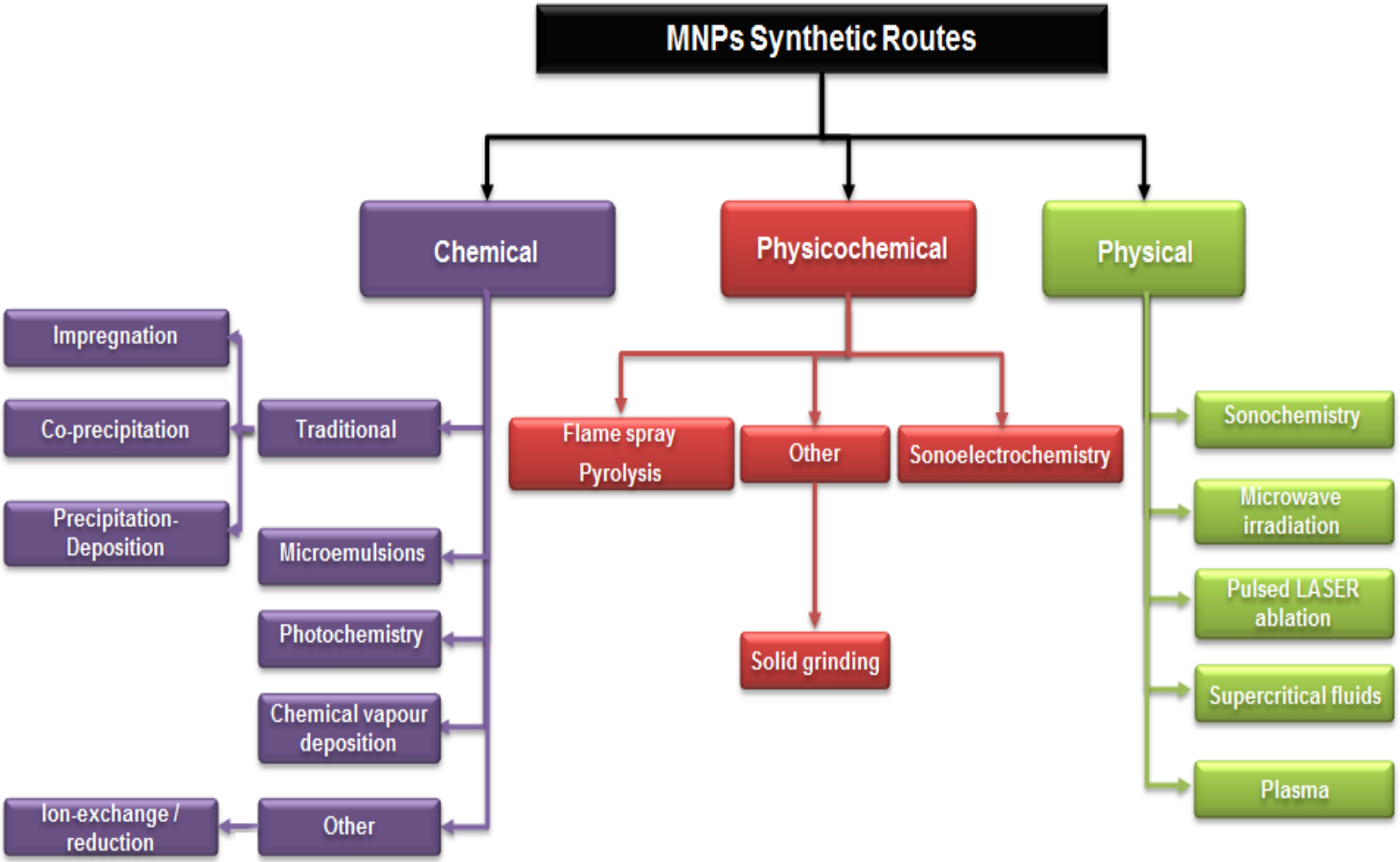
❖The use of environmentally beneficial material like plant leaf extract, bacteria, fungi and enzymes for the synthesis of Nnoparticles proposes abundant benefits of Eco friend lines and compatibility for pharmaceutical and many other biomedical application.

❖In recent times, the plant extracts are widely used as a viable and facile alternative strategy for the synthesis of metal Nanoparticles rather then other methods.

Different type process Synthesis of Nanoparticles



Different routes of synthesis of Nanoparticles

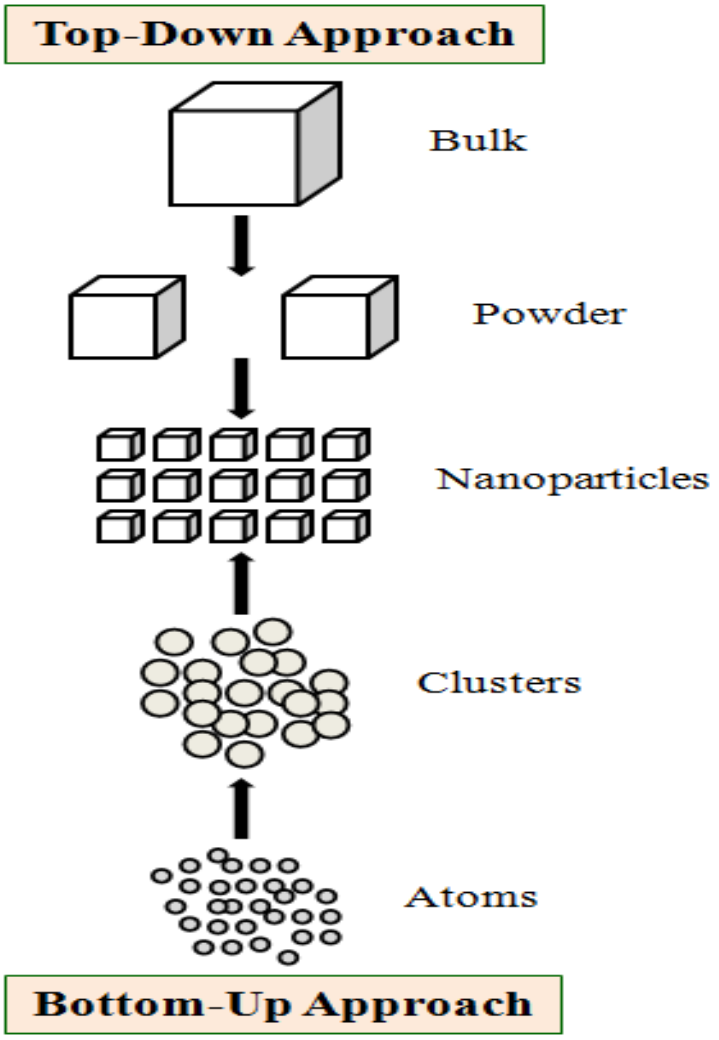


By Top down Approach:-

❖The top – down approach is a subtractive process starting from bulk materials to make nanomaterials. This approach involves division of bulk material or miniaturization of bulk fabrication process to produce the desired structure with the appropriate properties.

❖In general , top down approaches are easier to use and less expensive but have less control over the distribution and also could be destructive.

❖This include the methods are Attrition or Ball milling, Photolithography, Electron beam lithography, Machining etc.

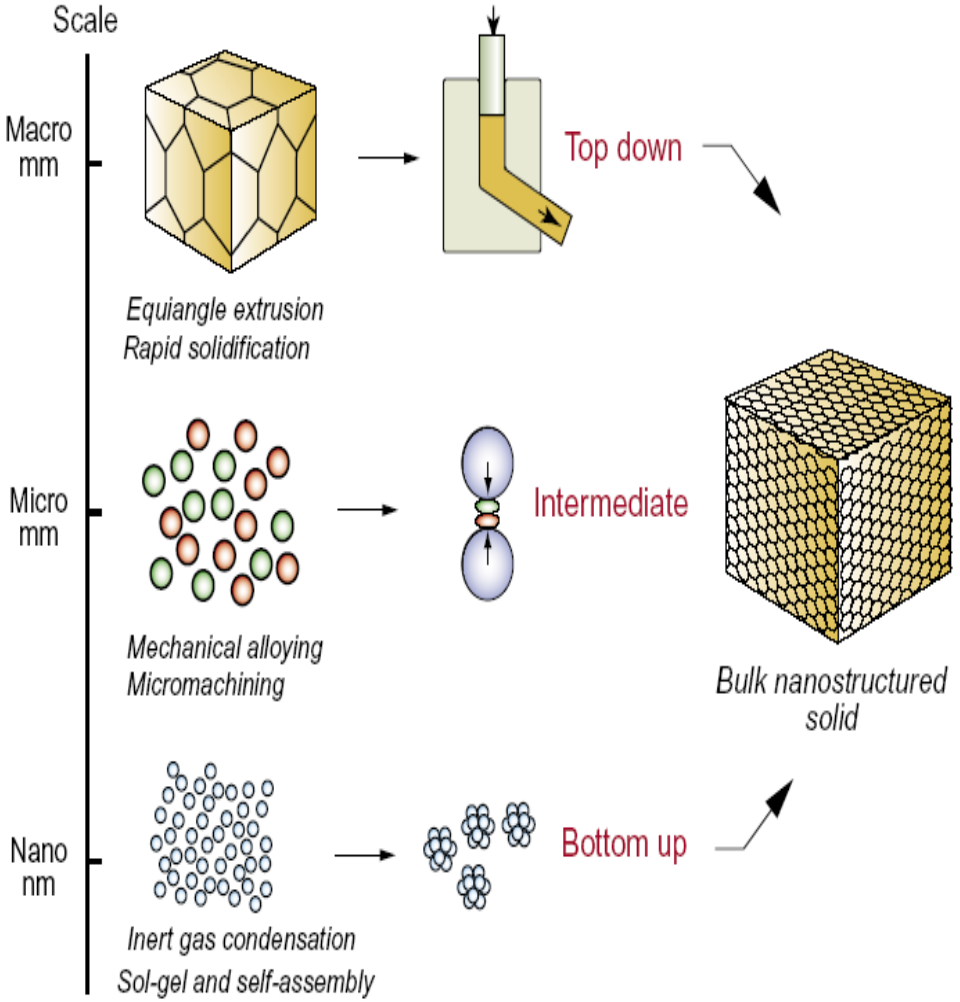


By Bottom up Approach:-

❖Bottom –up approach is a controlled additive process that deals with the assembly of precursor Atoms or molecules to make nanomaterials. In this approaches atoms, molecules or clusters are used as the building blocks for the creation of complexes Nanoparticles.

❖Bottom –up methods are chemically controllable and non – destructive. Bottom up approach usually employs solution- phase colloid chemistry for the synthesis. This method mostly used in Nanotechnology.

❖Some of the important methods involved are, Sol-gel, Vapour phase,Deposition, Chemical reduction Methods etc.



Characterization of Nanoparticles

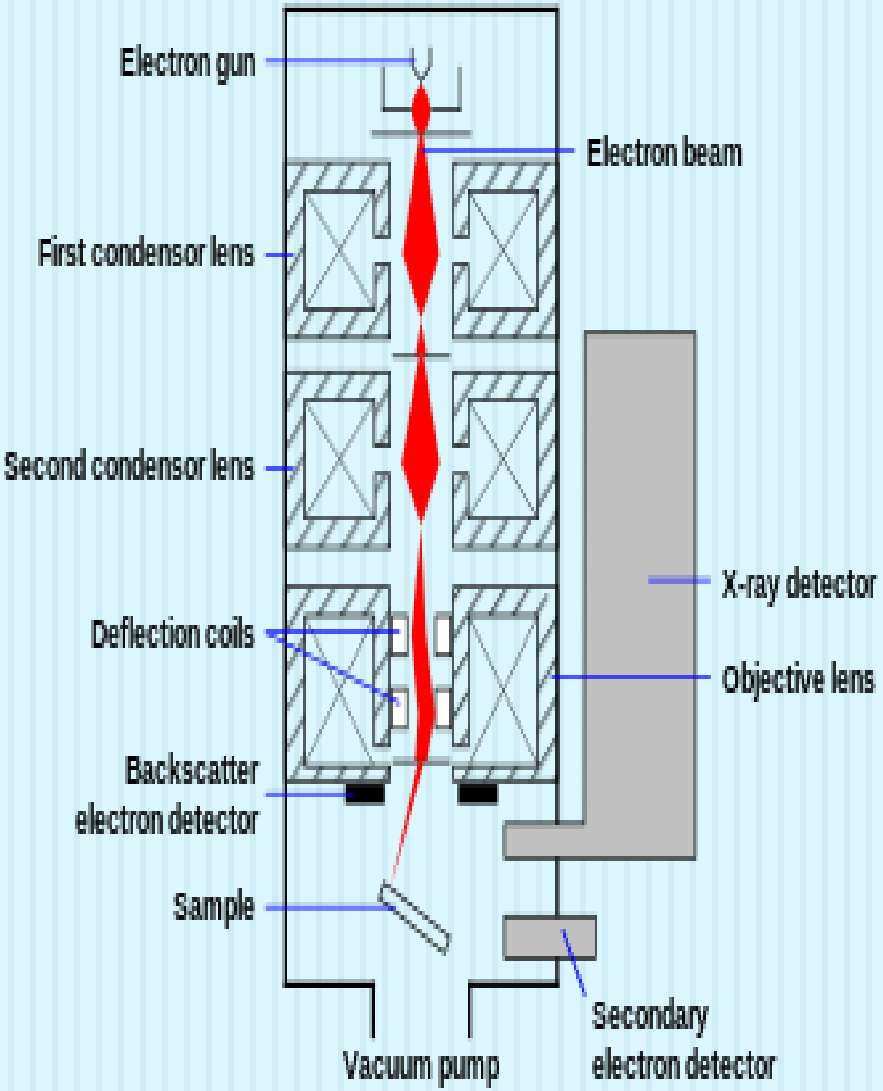
Microscopic Techniques:-

Scanning Electron Microscopy (SEM)

❖Scanning Electron Microscope is used to image and analyze materials of sizes that are less then micrometer range.

❖During SEM the signal is developed when electrons are interacted with the atoms that are at the surface of the materials.

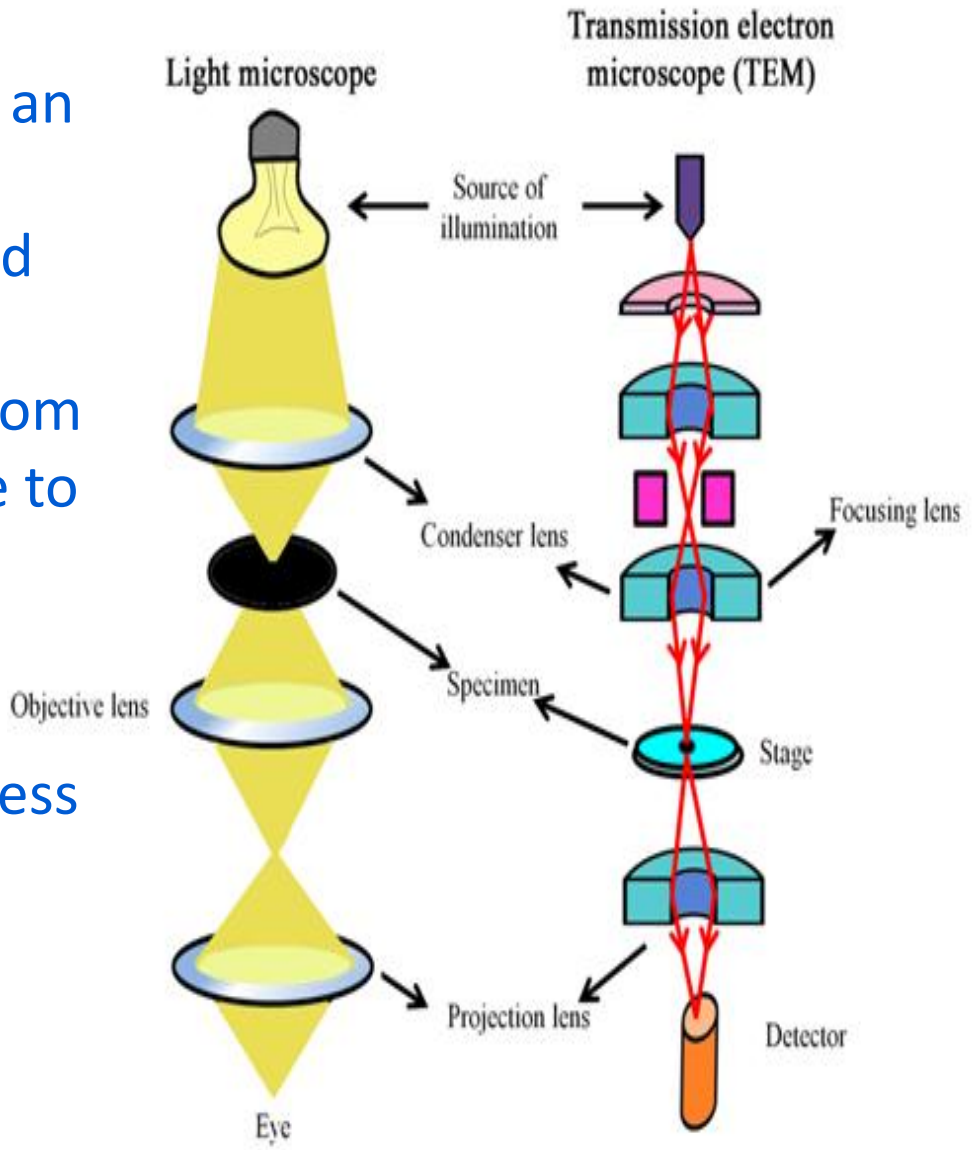
❖The signals show information about the sample including chemical composition, and crystalline structure, external morphology and orientation of materials which make up the sample and reveal information about the sample's composition, surface topography and other properties such as electrical conductivity



Transmission Electron microscopy (TEM)

❖The Transmission Electron Microscope are used to create an image of the sample .Electron beam instruments are operated under high level of vacuum to avoid scattering of electrons from their molecules and arcing due to high voltage.

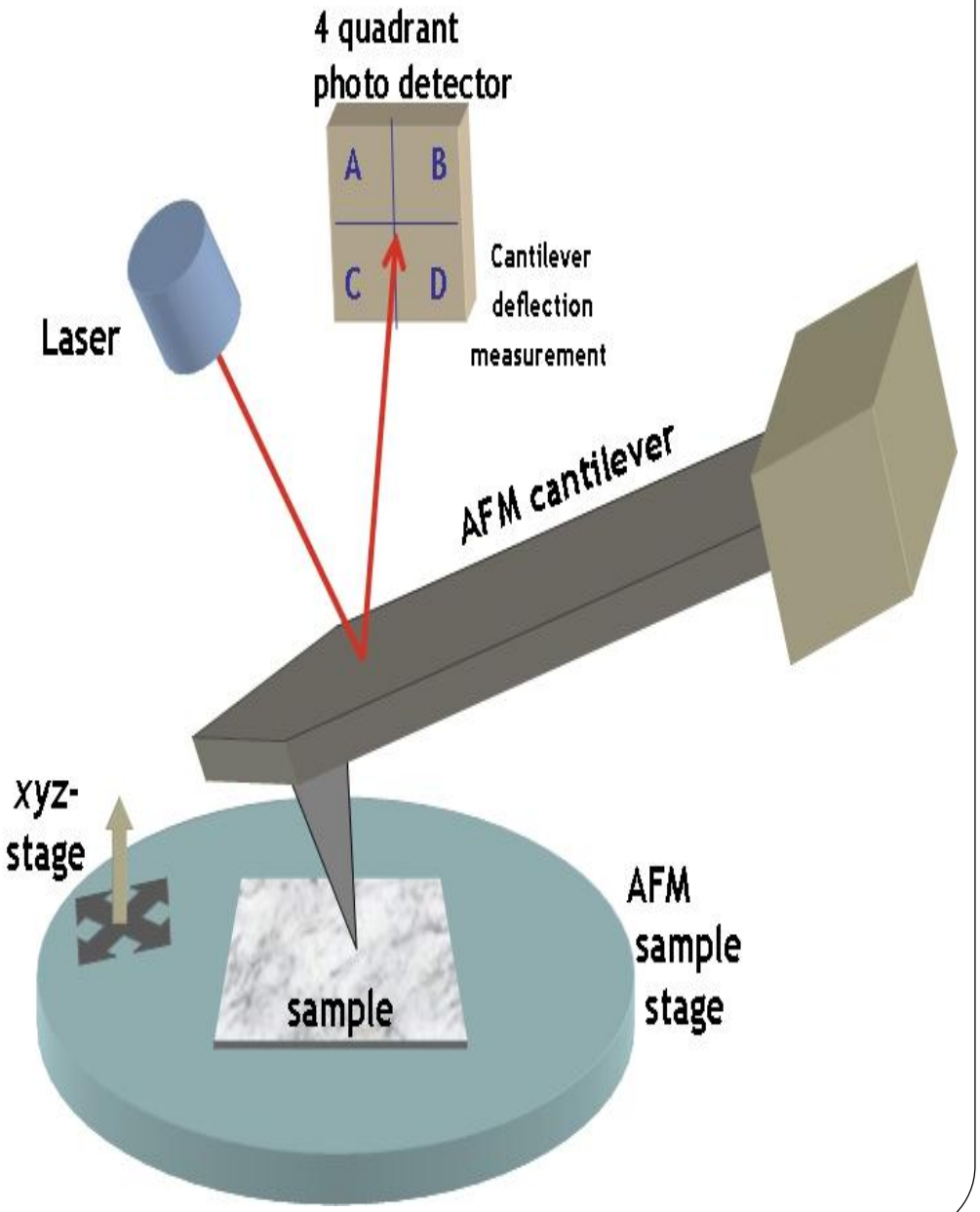
❖ A TEM probes the internal structure of solids to given access to the morphological fine structure details.



Atomic Force Microscopy (AFM)

❖Atomic Force Microscope can be used for the precise study of nanoscaled materials. AFM works by scanning an ultrafine ceramic or semiconductor probe over the surface of the material being analyzed .AFM or SFM is a very high-resolution type of scanning probe microscopy.

❖ A plot of the laser deflection versus probe tip position on the sample surface provides a highly resolved picture of the peaks and valleys of the sample surface, which constitutes, essentially, an atom-by atom topographical visualization of the material surface.

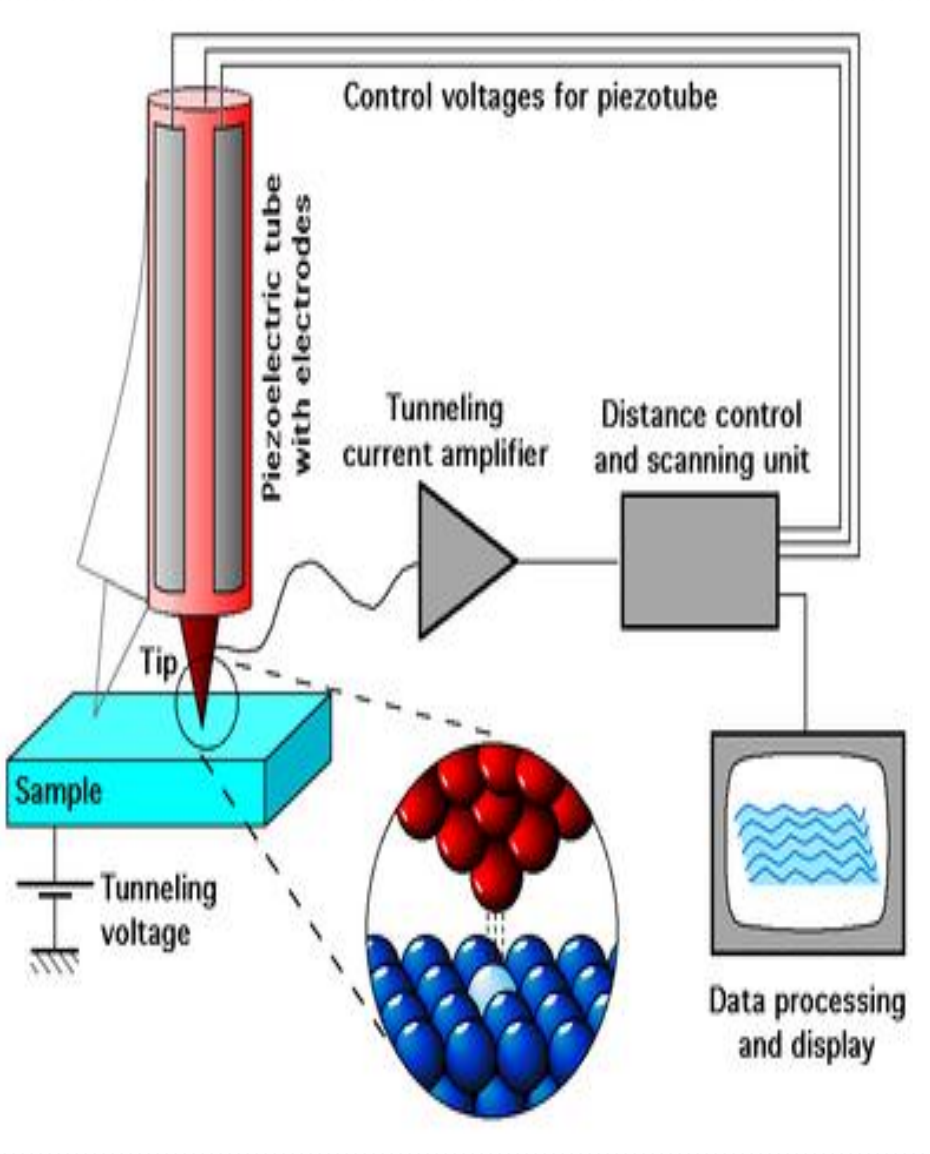


Scanning Tunneling Microscopy (STM)

❖Scanning Tunneling Microscope for imaging surface at the atomic level. For a STM, good resolution is considered to be 0.1 nm lateral resolution and 0.01 nm depth resolution. With this resolution, individual atoms within materials are routinely imaged and manipulated. The STM is based on the concept of quantum tunneling.

❖The STM can be used not only in ultra-high vacuum but also in air, water, and various other liquid or gas ambient, and at temperature ranging from near Kelvin to a few hundred degree Celsius.

❖STM can be a challenging technique, as it requires extremely clean and stable surface, sharp tips, excellent vibration control, and sophisticated electronics.



Scanning Probe Microscopy (STM)

- Scanning Probe Microscope is extensively applied to characterized nanostructures with atomic or subatomic spatial resolution.

- The SPM can be operated in a number of environmental condition, in a variety of different liquids or gases, allowing direct imaging of nanoparticles surfaces.

Spectroscopic Techniques

U-V Spectrophotometer:-

❖Ultraviolet- Visible spectrophotometer is designed to use light of ultraviolet and visible spectral region.

❖ This technique is used to determine the concentration of unknown solution and determination of transition metals whose electron transition energy that fall under U V or visible regions. This spectroscopy is used for quantitative analysis of the samples.

❖Nanoparticles dispersed in a solvent or embedded in the insulator matrix.

Scattering Techniques

Dynamic Light Scattering (DLS):-

❖Differential scanning calorimetry or DSC is a thermo-analytical techniques in which the difference the amount of heat required to increase the temperature of a sample and reference are measured as a function of temperature.

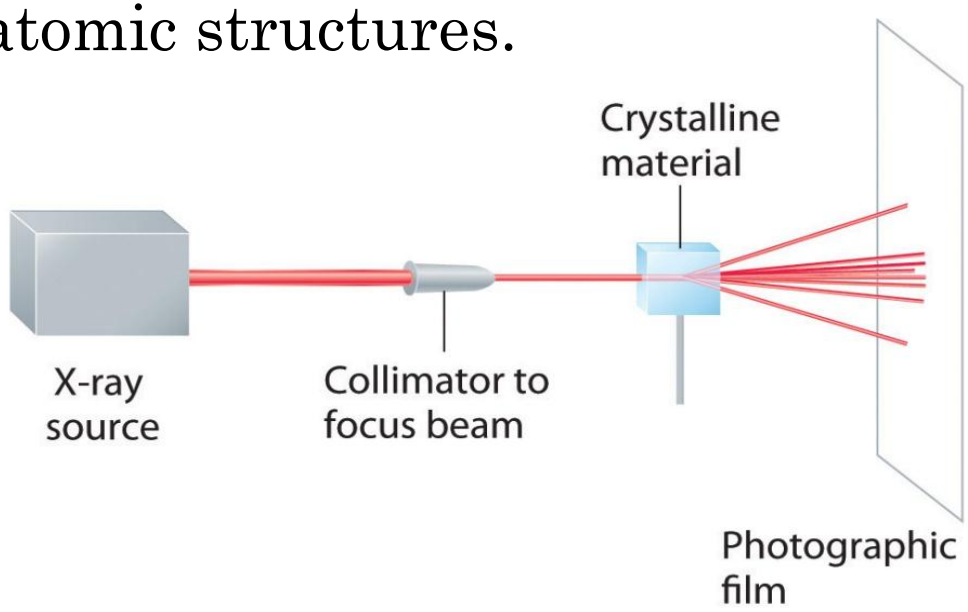
❖The main application of DSC is in studying phase transitions, such as melting, glass transition, or exothermic decompositions.

❖DSC may be also used to observe more stable phase changes, such as glass transitions. DSC is widely used in industrial setting as a quality control instrument due to its applicability in evaluating sample purity and for studying polymer curing.

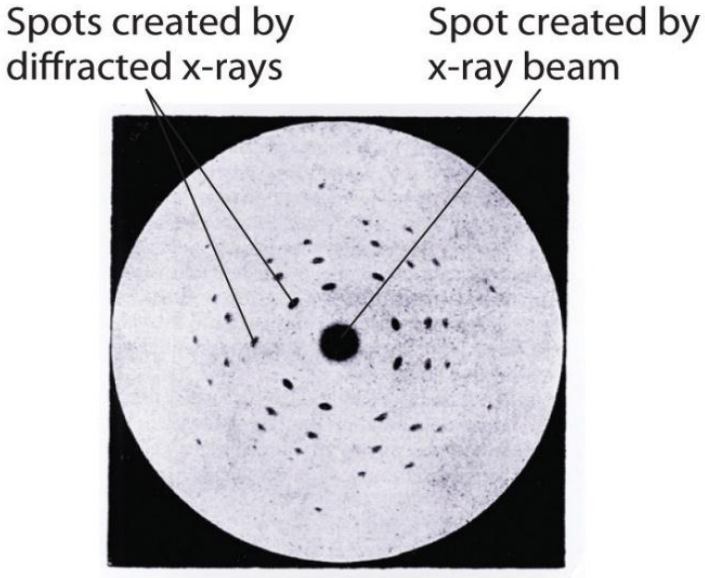
X- Ray Diffraction Scattering

❖X-Ray diffraction is a versatile, non-destructive analytical method for identification and quantitative determination of various crystalline forms, known as 'phases' of compound present in powder and solid samples.

❖X-Ray can be diffracted from minerals which, by definition, are crystalline and have regularly repeating atomic structures.



(a) X-ray diffraction

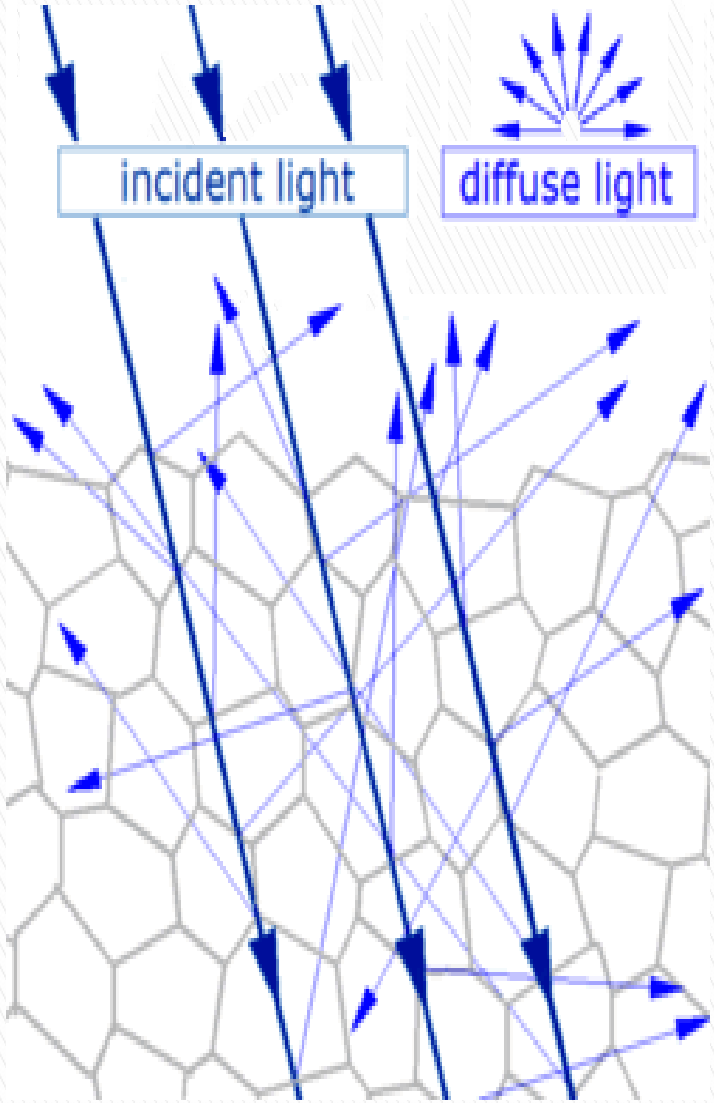


(b) X-ray diffraction pattern captured on photographic film

Light Scattering

❖Light scattering is a form of scattering in which light is the form of propagation energy which is scattered. Light scattering can be thought of as the deflection of a ray from a straight path.

❖Scattering of light depend on the wavelength or frequency of the light being scattered. Since visible light has wavelength on the order of a micrometer.



Application based Properties of Nanoparticles

Optical Properties:-

❖Optical properties have a great interest towards the vast application of optoelectronics, photovoltainic's and biological sensing. The arrangement of optical and semiconductor properties construct a doped Zink oxide which is a contender for new generation of devices.

❖Intrinsic optical properties of ZnO nanostructures are being intensively deliberated for the implementing photonic devices. ZnO is a wide band gap of 3.4eV semiconductors with a large exaction binding energy of 60 meV and also considered as one of the most promising semiconductor material for electronic, photonic, optical and biological applications.

❖Photoluminescence spectra show that the ZnO nanowire is a capable and promising materials for the UV emission. Its UV lasing property is additionally more significant and interesting.

Mechanical Properties:-

❖The mechanical properties of materials involve various concepts such as hardness, stiffness, and piezoelectric constant, Young's and bulk moduli, and yield strength.

❖The piezoelectric effect is understood as the linear electromechanical interaction between the mechanical and the electrical state in crystalline materials with no inversion symmetry. The piezoelectric effect is a reversible process in those materials exhibiting the direct piezoelectric effect.

❖The word piezoelectricity means electricity resulting from pressure.

❖The piezoelectric tensor has three independent components in hexagonal wurtzite phase and one in the cubic zink-blende phase, which characterize the full piezoelectric tensors of such crystals.

Electrical Properties:-

❖The fundamental study of the electrical properties of Zink oxide nanostructures is crucial for developing their future applications in nanoelectronics.

❖The advantages of a large band gap include higher values of breakdown voltages, sustaining large electric fields, high-temperature and high-power operations.

❖Successful p-type doping for Zink oxide nanostructure will greatly enhance their future application in nanoscale electronics and optoelectronics. P-type and n-type nanowires can serve as p-n junction diodes and light emitting diodes (LED).

Magnetic Properties:-

❖The changes in the magnetic properties of the nanocomposites can be accounted for by the modification of the average size of nanocrystallites with the Fe/Si molar concentration. The magnetic behavior of this sample is caused by its small crystallite size.

❖The surface effects are the result of finite-size scaling of nanocrystallites, which in turn leads to a non-co linearity of magnetic moments on their surface. These effects are more intense in ferromagnetic system.

❖The decrease is more pronounced with the increase in the surface –volume ratio of the nanocrystallites and the decrease in the average diameter of nanocrystallites, respectively. The observed behavior is condition by the magnetic structure that corresponds to a single-domain configuration of the crystallites.

APPLICATION OF NANOPARTICLES

In Field of Nanotechnology:-

- Nanotech solar cells are developed which are comparatively of lower cost than the conventional solar cell.

- Solar steam light is a successful invention of nanotechnology which is useful in water purification and disinfecting.

- The wires with carbon nanotubes are lower resistance than the wires of electric transmission grid that is possible by Nanotechnology.

In Field of Cancer Therapy:-

- The nanoparticles which deliver chemotherapy drugs directly to the cancer cells are under development.

- The magnetic nanoparticles attach to the particles in the blood stream known as micro vesicles which originate in brain cancer cells.

- The iron nanoparticles can used to improve the MRI techniques of the cancer cells.

- Bismuth nanoparticles are used for the radiation therapy for the treatment of cancer.

- The carbon nanotubes and gold nanoparticles are being used in a sensor which detects proteins investigative of the oral cancer.

In Field of Drug Delivery:-

❖The diagnosis of early detection of the kidney damage is being developed by the use of gold nanorods.

❖Functionalized metals with proteins have been used biolabels for antibody molecule coated gold particles of 10-40 nm size are routinely used in histology as boilable.

❖Nucleic acid coated nanoparticles can be used as sensors in biomedical diagnosis such sensor can detect pathogenic nucleic acids.

❖Nanocrystal acts as an antimicrobial agent for the treatment of wounds. The silvers nanocrystal is used as an antimicrobial agent for the treatment of wounds.

In Engineering's:-

- The nano engineered polymer matrix is used for light tubes with high efficiency which is shatter proof and has the capability of efficiency of compact fluorescence light bulbs.

- Engineered nanoparticles are intentionally designed and created with physical properties tailored to meet the need as in the case of quantum dots or pharmaceutical drug.

- None engineered nanoparticles, on the other hand are unintentionally generated or naturally produced such as atmospheric nanoparticle created during combustion

RESULTS / CONCLUSION

Nanoscale science and technology is a young developing field of science and engineering. With rapid advances in areas such as molecular electronics, synthetic biomolecular motors, DNA-based self- assembly, and manipulation of individual atoms via a scanning tunneling microscope, nanotechnology has become the principal focus of a growing cadre of scientist and engineers and has captured the attention and imagination of the general public.

In recent years there are many scientific interests in the field of Nanoscience and Nanotechnology. Many of researchers have worked a lot in this field. Different synthetic routes have been proposed for synthesizing the different types of Nanoparticles .The Nanoparticles have been characterized by the different microscopic, spectroscopic, scattering and other techniques.

TANKS FOR YOUR KIND ATTENTION

K.M.AMISH