DATED : 16/05/2020

ASSIGNMENT - 6

INNOVATIVE TECHNOLOGY & BIOSCIENCES

Submitted by : YASH VINAYVANSHI
B. TECH 2nd SEM
SECTION 'C' ; SR-NO.: 72
ROLL NO.: 19BCS081
JAMIA MILLIA ISLAMIA
E-mail : yash-vinayvanshi@gmail.com

Submitted to : PROF. KEHKASHAN PARVEEN
DEPT. OF APPLIED SCIENCE & HUM.
JMI FET.

Q1. Explain properties of nanomaterials.

The chemical & Physical properties of Nanomaterials (such as optical Absorption and fluorescence, melting point, catalytic activity, magnetism, electric & thermal conductivity etc.) differ significantly from their corresponding coarser bulk materials. A wide range of material properties can be adjusted by structuring at the nano scale:

PROPERTY	EXAMPLE
1. Catalytic	Better catalytic efficiency through high surface to volume ratio.
2. Electrical	Increased electrical conductivity in ceramics and magnetic nanocomposites.
3. Magnetic	Increased magnetic coactivity upto a critical grain size, super paramagnetic behaviour.
4. Mechanical	Improved hardness & toughness of metals & alloys, ductility and super plasticity of ceramic.
5. Optical	Spectral shift or optical absorption and fluorescence properties. Increased quantum efficiency of semiconductor crystals.
6. Sterical	Increased selectivity, hollow spheres for drug transportation & controlled release
7. Biological	Increased permeability through biological barrers, improved biocompatibility.

It is seen that reactivity of nanoparticles increase with decrease in particle size, melting temperature of nanophases is considerably lower than their bulk counterparts; the colour of a nanoparticle (especially semiconductors) changes with its size. At times, a particle could behave as metallic or semi-conducting depending on its size. The finite charge of particle confines the spatial distribution of the electrons, leading to quantised energy levels due to size effect. This quantum confinement has applicns in semiconductors, opto-electronic & non-linear optics.

Some Properties of Nanomaterials are described below:

1. OPTICAL PROPERTIES

(i) Colloidal solutions of spherical gold nano-particles exhibit a deep red colour due to the well known surface plasmon absorption. The surface plasmon resonance is caused by the coherent motion of conduction band electrons which interacts with an electromagnetic field. Noble metals such as Cu, Ag, Au have strong visible light plasmon resonance, whereas most other transition metals show only a broad and poorly resolved absorption band in the UV region

(ii) Another interesting effect is size quantisation in semiconducting nanoparticles. As their size is reduced in dimensions (< 5nm) comparable to an exciton diameter, the energy gap between the valence & the conduction band increases. Consequently, the optical absorption shows a blue shift.

2. CHEMICAL & PHYSICAL PROPERTIES

(i) Reduction in particle size enhances self diffusion, solute diffusion and solute solubility in nanomaterials. Enhanced diffusivity and solubility can be attributed to defective atomic coordination at the grain boundaries in nanocrystals. The higher fraction of grain boundries in nanocrystals also results in higher values of specific heat compared conventional polycrystals.

(ii) The large surface to volume ratio of nanocrystals greatly changes the role played played by surface atoms in determining their thermodynamical properties.

(iii) The reduced coordination number of surface atoms greatly increases the surface energy so that atom diffusion occurs relatively at low temperatures. Consequently reactions are much faster.

(iv) Nanocrystals usually have faceted shape and mainly enclosed by low index crystallographic planes. The density of surface atoms changes significantly for different crystallographic planes, possibly leading to diffn thermodynamic properties.

3. ELECTRICAL & MAGNETIC PROPERTIES

(i) Various properties exhibited by oxide nanoparticles are consequences of size reduction. The enhancement in electrical conductivity is predicted for nanosized conducting ceramics as a result of space charge contribution from the interfaces. Size effects play a crucial role in influencing domain dependent magnetic & dielectric properties.

(ii) Magnetic materials exhibit size dependent properties that range from ferromagnetic to paramagnetic to super paramagnetic with decreasing size. The magnetic properties of nanoparticles differ from those of bulk mainly in two points: The large surface to volume ratio results in a different local environment for the surface atoms in their magnetic coupling/ interaction with other atoms, leading to mixed volume and surface magnetic characteristics. Unlike bulk ferromagnetic materials which usually form multiple magnetic domains, several ferromagnetic particles could consist of only a single magnetic domain. In case of single particle being single domain, the superparamagnetism occurs, in which the magnetisation of particles are randomly distributed and they're alligned only under an applied magnetic field and allignment dissappears once external field is withdrawn.

4. MECHANICAL PROPERTIES.

(i) It is known that magnetic properties of a solid depends strongly on the density of dislocations, interface to volume ratio and grain size. A decrease in grain size significantly affects the yield strength & hardness. The grain boundary structure, boundary angle, boundary sliding, and movement of dislocations are important factors that determine the mechanical props of nanostructured materials. One of the important applicns of nanomaterials is superplasticity, the capacity of a polycrystalline material to undergo extensive tensile deformation without necking or fracture.

(ii) The improved ductility of a brittle ceramic oxide when prepared in nanocrystalline form is worth noting. The enhanced interdiffusion among the grains in nano crystals helps the grain boundaries to slide by one another, thereby increasing ductility.

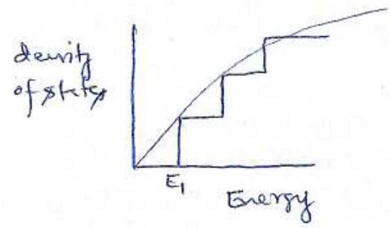
(iii) Grains are crystallised domains that combine to form a larger poly crystalline ~~material~~ particle. As grain size approaches the particle size, we have single crystal nanoparticles. Except for a single crystal nanoparticle, the nanoparticles have randomly oriented grains. The higher density of consolidated nanophase material is attributed to filling space tightly by enhanced diffusion. The random orientations also suppress the dislocation motion in these materials.

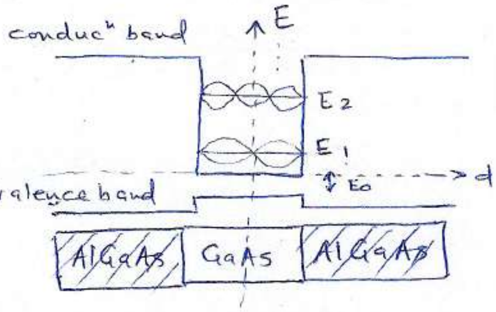
Q2. Define quantum well, quantum wire and quantum dot with examples.

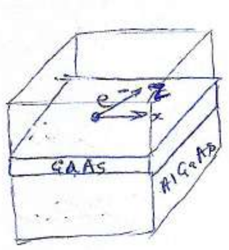
1. QUANTUM WELLS

Quantum wells are heterostructures in which a thin layer (sufficiently thin such that quantum interference effects begin to appear prominently in the motion of electrons) of one semiconductor is sandwiched between two layers of a different semiconductor material, thereby forming a heterojunction. Materials are chosen such that electrons available for conduction in middle layer have lower energy than those in outer layers, creating an energy dip (or well) that confines electrons in the middle layer. This is possible since differences in energy gap permit spatial confinement of electrons and holes injected into the middle layer. The electron wavefunctions in such a well consist of a series of standing waves.

eg. quantum well created by sandwiching GaAs b/w AlGaAs whose energy band profile is as

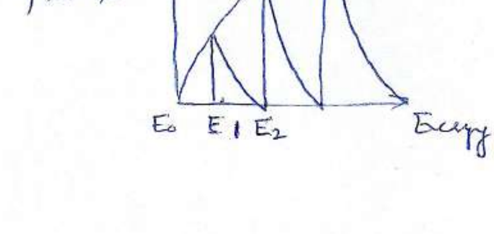


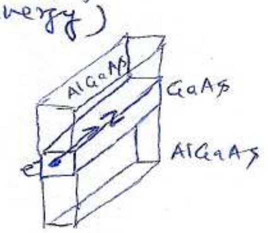




2. QUANTUM. WIRE

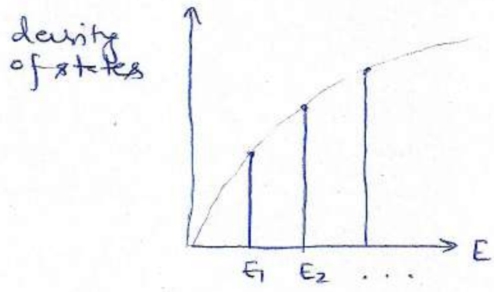
A quantum wire is an electrically conducting wire in which quantum effects influence the transport properties. Usually, such effects appear in dimension of nanometers, so they are called nanowires. In these narrow structures, electron transport is possible in a very few transverse modes (with energies less than fermi energy)

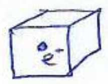




3. QUANTUM DOT

These are small semiconductor particles a few nanometers in size, having optical & electronic properties that differ from larger particles due to quantum mechanics. Nanoscale semiconductor materials tightly confine their electrons or electron holes. Quantum dots having bound, discrete electronic states, like naturally occurring atoms or molecules. It is shown that the electronic wavefunctions in quantum dots resembles ones in real atoms → these are called artificial atoms. By coupling two or more such quantum dots an artificial molecule can be made, exhibiting hybridisation even in room temperature. Quantum dots have properties intermediate between bulk semiconductors & discrete atoms / molecules. Their optoelectronic properties change as a func of both size & shape. Eg. ZnS quantum dot.





Q3. What do you understand by molecular nanotechnology.

Molecular nanotechnology describes engineered nanosystems (nanoscale machines) operating on the molecular scale. It is especially associated with the molecular assembler, a machine that can produce a desired structure or device atom by atom. using principles of mechanosynthesis - mechanically guided chemical synthesis - is fundamental to molecular manufacturing. The projected applications of molecular nanotechnology include: Smart materials & nanosensors (material engineered and designed at nanometer scale for a specific task), replicating nanobots, medical nanorobots and Phased array optics. The potential impacts of Molecular nanotech. include: manufacturing things which were previously limited by manufacturing limits, producing molecular computers etc.

— x —

YASH VINAYVANSHI