# Nanoscale rare earth metal oxide semiconductor, properties, preparation methods and its applications

**R. Thirumamagal1\*, U. Ashokan1, A. Ayesha Mariam2**

1 Department of Physics, Ananda College, Devakottai.

2 P.G and Research Department of Physics, Kadhir Mohaideen College, Adhirmpattinam

# Abstract

The properties of metal oxide semiconductor materials change excessively when its size is reduced to nanoscale due to their large surface area or quantum size effect. The nanostructured metal oxide semiconducting materials reserves excellent redox property. In recent days rare earth lanthanides metals like (La, Ce, Pr, Nd ) have a well-known catalyst for oxidation reactions as well as potential candidate as stabilizing agent of hydroxyapatite in the crystalline phase, one decided to generate a mixed hydroxide material that can be electrochemically activated generating metal oxide semiconductor compassing synergic catalytic effects for oxidation of hydroxyapatite and organic molecules. Metal oxide semiconducting nano structured materials acts as a vital role in the development of modern technology and lead to significant breakthrough in the semiconductor industry like renewable energies, solar fuels, photovoltaic effect, eight emitting nano devices, and laser technology. Synthesized composites having good influence on the properties of sensing and inhibition ability on microbial activity. Modifying sensing materials is one kind of doping strategy to improve the sensing properties of metal oxide-based gas sensors. Metal oxide with hydroxyapatitie nano composites revealed that the binary cytotoxicity of the composite mixture should mediate their direct contacts and the subsequent Cytotoxicity.

# Introduction

Nanoscience is that the study of nanoscale materials: materials which exhibit remarkable, properties, functionalities and phenomena because of the influence of small dimensions. Technology refers to the sensible application of knowledge- development, applications and commercial implications. Nanotechnology relies on manipulation, control, integration of atoms and molecular style of materials, structures, components, devices and systems at nanoscale. it's the appliance of nanoscience to industrial and commercial objectives. Nanoscience and nanotechnology are two research areas coping with materials of nanoscale - and are multi-disciplinary areas integrating physics, chemistry, engineering and biology. Nanoparticles behave so very differently from once they are bound in larger units.

Nanotechnology aims to form a study of those characteristics, to seek out laws of governing these characteristics, to integrate such knowledge, deriving theoretical model to explain them and to analyse the properties of them. Nanotechnology is engineering these objects at their molecular level by using different techniques. The aim is to use the properties at the molecular level to be more efficient. It focuses on properties like strength, lightness, electrical and thermal conductance and reactivity, to manufacture for useful items [1].

It employs two approaches namely Top down approach and a Bottom up approach.  
Various concepts like self-assembly, and molecular machines also are employed in nanotechnology. Nanoparticles have unique properties compared with their bulk. Their properties are often controlled by simply tuning their sizes, shapes and compositions. These novelties don't seem to be simply because of reducing their size; it comes from alternative ways that depends on kind of material. Origins are: (i) Quantum size effect and (ii) Surface atom effect.

**Quantum size effect**

Quantum confinement effect induces changes in bandgap energy and quantization of electronic energy. When a particle size approaches the Bohr exciton radius, the energy gap becomes widened with the decreasing particle size and this property will enhance optical properties much.

**Surface atom effect**

The ratio of surface atom to bulk increases sharply with the decrease in particle size. This imperfect surface of nanoparticles provides surface defects that are even mor e active and might provide additional electronic states and reactivity i.e. when the dimensions of the fabric decreases to nanoscale, total expanse per unit mass increases.

**Properties of Nanoparticles**

Due to their novel properties and varied potential applications, nanocrystalline materials with typical grain sizes <100 nm, are attracting and increasing attention from researchers everywhere in the globe [2]. The little grain size of those materials, and consequently the big volume fraction of atoms in or near the grain boundaries, these materials exhibits the properties that are often superior, and sometimes completely new, compared to those of conventional coarse-grained materials.

These can affect the optical, electrical and magnetic behaviour of the materials, because the structure or particle size approaches the smaller end of the nano-scale. Materials that exploit these effects include quantum dots, and quantum well lasers for opto-electronics.

Nanoscience and nanotechnology have grown explosively within the last decade thanks to the increasing availability of methods of synthesizing of nanomaterials similarly as tools for characterization and manipulation. Several innovative routes for synthesizing nanoparticles and nanotube assemblies are now available. The size-dependent electrical, optical and magnetic properties of individual nanostructures of semiconductors metals and other materials and better understood. Besides the established techniques like microscopy, crystallography and spectroscopy, scanning probe microscopies have provided powerful tools for the study of nanostructures [3].

Nano structures constitute a bridge between molecules and infinite bulk systems. Individual Nano structures include clusters quantum dots nano crystals, nanowires and nanotubes, while collections of nonstructural materials involve arrays, assemblies, and super lattices of the individual nanostructures. The physical and chemical properties of nanomaterials can differ significantly from those of the atomic molecular composition are shown in Table 1 [4].

**Table -1 Nano strcutures and their assemblies**

|  |  |  |
| --- | --- | --- |
| **Nanostructure** | **Si Size** | **Material** |
| Clusters, nanocrystals quantum dots | Radius 1-10nm | Insulators, semiconductors metals, magnetic materials. |
| Other nanoparticles | Radius  1-100nm | Ceramic Oxides |
| Nano biomaterials, Photosynthetic reaction center | Ra Radius 5-10nm | Metals, semiconductor oxides, sulfides, nitrides |
| Nanowires | Diameter  1-100nm | Carbon layered chalcogenide BN, GaN |
| Nanobiorods | Diameter  1-100nm | DNA |
| Nanotubes | Diameter 5nm | Carbon, layered chalcogenides Material BN,GaN |
| Two dimensional arrays of nanoparticles | Area  Several nm2-μm2 | Metals, semiconductors, Magnetic Materials |
| Surface and thin films | Thickness  1-100nm | Insulators, semiconductors metals, DNA |
| 3-dimensional super lattices of nanoparticles | Several nm in 3 dimensional | Metals, semiconductors, Magnetic Materials |

Some of the important concerns of materials science within the nanoscience area are

i. Nanoparticles or nanocrystals of metals and Semiconductors, nanotubes, nanowires and nano biological systems.

ii. Assemblers of nanostructures and therefore the use of biological systems, like DNA as molecular nanowires and templates for metallic or semi conducting nanostructures.

iii. Theoretical and computational investigations that provide the conceptual framework for structure dynamics, response and transport in nanostructures.

iv. Application of nanomaterials in biology, medicine, electronics, chemical processes, High - strength materials etc.

**Nanoparticles**

Nanoparticles are small clusters of atoms about 1 to 100 nanometers long. Nano derives from the Greek word nanos, which mean on extremely small. Nano particles are larger than a private atom and a molecule but are smaller than bulk solid. Hence they obey neither absolute quantum chemistry nor laws of classical physics and have properties that differ markedly from those expected. The 2 major phenomena that are liable for these differences, is that the high dispersity of nanocrystalline systems. because the size of the crystal is reduced, the amount of atoms within the surface of the crystal compared to the amount of atoms within the crystal itself, increases. as an example, a 4 nm (Cds) mineral diameter has about 1500 atoms, of which a couple of third are on the surface which are usually determined by the molecular structure of the majority lattice, now become increasingly dominated by the defect structures of the surface [5]

Template synthesis methods like alumina-porous membranes and track-tched polycarbonate porous membranes, to electrochemically deposit metal nanoparticles insides the pores has become popular within the recent years. These deposits are studied within the context of a good spectrum of scientific goals starting from catalysis to magnetic properties and magnetic data storage. Attention has also been focused on the applying of small metal particles in surface enhanced spectroscopy photo catalysis and selective solar absorbers studies with atomic absorption have shown that iron, nickel, cobalt and gold particles have equivalent areas per volume with particle radii within the range 3 to five nm. Magnetic measurements on iron, nickel and cobalt films-reveal them to the highly anisotropic with magnetization perpendicular to the surface of the film. The weird optical absorption of noble-metal nanoparticles like copper, silver and gold embedded in a very dielectric medium like alumina renders them of interest for optical applications Electro Chemical nucleating also plays a task in nanoparticle fabrication of metal nanoparticles at template liquid interfaces [6].

To fabricate a metallic shell around a nanoparticle, the methods employed are like the reverse micelle, thermal decomposition method, Photo-decomposition method and electrochemical displacement method are reported [7]. The chemical reaction is dispensed in neutral organic solutions or in an aqueous electrolyte through the employment of hydrophilic surfactant groups extending from the metal core. The resulting core shell nanoparticles have potential applications in magnetic medium and also as drug-delivery systems. However, both the electro less and displacement depositions have one basic characteristic in common; no power supply is important to drive the deposition reaction. In brief, the reaction deposition are often distributed with noble-metal ions reduced by the nanoparticles [8].

# Properties of Rare-Earth Metal Oxide Nanoparticles

A series of lanthanon metal oxide (CeO2, Pr2O3, and Nd2O3) nanoparticles, which has been act as a vitamin for semiconductor industry and a ‘treasury’ of recent born materials. It has an inherently critical role in technical progress and therefore the development of technical industries, and it's also widely applied in high-technology industries like information and biotechnology [29]. The chemistry of group differs from main group elements and transition metals due to the character of the 4f orbitals, which are ‘buried’ inside the atom and are shielded from the atom’s environment by the 4d and 5p electrons. [29,30]. These orbitals give grouping unique catalytic, magnetic and electronic properties. These unusual properties is exploited to accomplish new varieties of applications that aren't possible with transition and main group metals.

**Nano particle preparation methods**

**Solution precipitation procession of nanoparticles**

Precipitating clusters of chemical compounds from an answer of chemical compounds has been a gorgeous proposition for researchers primarily gives to the simplicity with which experiments may be conducted in an exceedingly laboratory. This is often very true if the goal is to only have a nanocrystalline powder rather than a dispersible nanopowder particle. A significant advantage of solution processing is that the ability to make encapsulated nanoparticles, specifically with an organic molecule, for providing functionality to the nanoparticles improving their stability in an exceedingly medium or for controlling their shape and size [14].

Solution processing are often classified into three major categories

(i) Sol-gel processing

(ii) Precipitation Method

(iii) Hydrometallurgical method

(iv) Jet Nebulizer technique of Nps

**(i) Sol-Gel processing**

Sol-gel technique is one among the foremost popular solutions processing method for producing metal oxide nanoparticles. Over the years, solution precipitation and sol-gel processing have come to be used interchangeably mostly by people on the fringes of the technical community. There are distinct differences between two methods as are going to be made clear below. In sol-gel processing a reactive metal precursor like metal alkoxide, is hydrolyzed with water and hydrolyzed species are allowed to condense with one another to create precipitates of metal oxide nanoparticles. The precipitate is subsequently washed and dried, which is then calcined at an elevated temperature to create crystalline metal oxide nanoparticles.

The hydrolysis of metal alkoxides involves nucelophilic reaction with water, which is as follows M(OR)y + xH2O+M(OR)y-x(OH)+xROH

**(ii) Precipitation**

Chemical and physiochemical methods of metal powder production allow great variations in powder properties. The large choice of processing variables and production parameters currently available permit close control of particle size and shape. Powders made by reduction of oxides, precipitation from solution or from a gas, thermal decomposition, chemical embitterment, hydride decomposition and thermit reactions belong to the current classification. the foremost widely used processes within this category include oxide reduction precipitation from solution and thermal decomposition.

The assembly of iron, copper, tungsten and molybdenum powders from their respective oxides is that the well-established commercial process. Detailed process descriptions for these oxide-reduced powders are found within the articles “production of iron powder”. For the assembly of copper powder of refractory metal and carbide powders on a smaller scale, this oxide reduction process is employed and is also used for production of cobalt and nickel powders in addition.

Oxide-reduced powder grades of iron and copper compete with powder grades made by other processes. Oxide-reduced powders characteristically exhibit the presence of pores within each powder particle and thus are called sponge powders. This sponginess is controlled by the number and size of the pores and accounts for the great compatibility and sinterability of such powders [15].

These chemical reactions can potentially control the mobility and toxicity of trace metals in soil systems.

**(iii) Hydrometallurgical method**

Production of metal powders by hydrometallurgical processing relies on leaching an ore or ore concentrate, followed by precipitating the metal from the leach solution. Although basic precipitation reactions are known for over 100 years, commercial use of this process didn't flourish. Metal precipitation from solution are often accomplished directly by electrolysis cementation or chemical reduction. Indirect precipitation could also be achieved by first precipitating a compound of the metal followed by heating, like decomposition and reduction. The foremost widely used commercial processor supported hydrometallurgy is copper cementation and also the separation and precipitation of copper nickel and cobalt from their respective salt solutions by reduction with hydrogen.

In its simplest form, copper cementation recovers copper from acidic dump that reaches solutions as an impure powder precipitate. because of the presence of serious amounts of iron and silicates, low apparent density and high green strength, such copper powders find use in P/M friction composite components. they're not utilized in conventional structural parts thanks to insufficient sintering activity.

**iv)Jet Nebulizer technique of NPs**

## 

## Figure 1 jet nebulizer technique

## 

## The Jet nebulizer contains three main parts as detailed in Figure 1, which may be easily dismantled and assembled. the primary part is that the bottom portion having an inlet for compressed gas and micro air nozzle with a diameter of 0.5mm. this is often the important a part of this nebulizer. When air at high applied through this nozzle, it acts sort of a jet air nozzle and air is relished from it with very high speed. this can be the rationale for the name as ‘Jet Nebulizer’. The second part is specially designed liquid sucking unit with a little hole and a striker target basketball shot the highest portion and this can be mounted on the primary a part of Jet air nozzle. Third one is that the top portion having an outlet of 1cm diameter for the discharge of aerosols and also with a 1 cm diameter tube from top to bottom. The Figure 2 shows the photograph of Jet Nebulizer experimental founded.



Figure 2 Photograph of experimental technique

The chemical liquid which is to be sprayed should fill at the underside portion of the Nebulizer. The filling of the liquid is poured through the opening of apex of top portion’s tube. When the compressed gas applied to the underside portion, it'll be released through Jet air nozzle with very high speed. Now, the liquid within the bottom portion will make a move towards the junction of the Jet nozzle and therefore the second portion through the capillary rise movement because of the vacuum produced at junction by the Jet nozzle speed of the air. While the liquid reaches the junction it mixed with the speedy air and subject to impinge on striker target tip point. thanks to this very high speed collision the fragmentation of the liquid starts and moved horizontally towards the walls of the primary portion. Here the further fragmentation caused by second collision on the side walls and therefore the liquid formed as aerosol sized droplets like mist, which moved towards the outlet. because of the collision with the straighter target tip and horizontal movement of the liquid fragmentations a tiny low vacuum created on the highest portion of the tip and hence automatically the air are going to be sucked through the 1 cm diameter tube within the top portion of the Nebulizer. This air also added with the mist and moved towards outlet with very high speed.

The mist output initiating from the Nebulizer towards thorough the specially designed spray nozzle falls on the substrate which is placed inside the furnace maintained with the temperature range of 300°C to 500°C. the gap between the spray nozzle and therefore the substrate optimized at 5 cm for better coating.

The standard of the film depends on various process parameters and hence it's essential to optimize each process parameter to urge good quality films. within the present work the air rate of flow and substrate to nozzle distance were optimized by trial and error method. When the gap between the substrate to nozzle changes, the thermal gradient within the vapour space changes, hence the thermophoretic force working on the liquid droplet will change. within the Jet nebulizer spray pyrolysis when the droplet (mist) approaches the substrate it should vaporize entirely just above the substrate: this can be the deal condition for the most effective transportation of the species to the substrate. Assuming that the scale distribution of all the droplets is that the same, the thermal energy gained by the droplets will increase greatly with increasing substrate to nozzle distance. This leads to the preheating of the droplets by carrier gas through heat radiation. it's known that preheating enhances the pyrolytic reaction. Therefore, it seems likely that, at a substrate to nozzle distance of 5 cm heterogeneous reaction takes place because of the pre-heating of the optimized droplet size and hence good quality films were obtained. Above 5 cm substrate to nozzle distance, the thermal energy gained by the droplet is extremely high. This causes the water molecule, which is that the important oxidizer within the pyrolytic decomposition, to vaporize completely secluded from the substrate. The particle melts and vaporizes (or sublimes) and a chemical process will occur within the vapour phase. this is often a homogeneous reaction, because all the reactant molecules and merchandise molecules are within the vapour phase. The molecules condense as microcrystallines, which form a powdery precipitate on the substrate. This powder disturbs the formation of the layer and ends up in a discount in transmission. additionally, the homogeneous reaction diminishes the deposition efficiency [16].

For the above, to optimize the gap between the spray nozzle and also the substrate by trial-and-error method, ranging from 10 cm to 2 cm, the space gradually decreased from 10 to 7 cm, the mist isn't ready to reach the substrate because of heat waves. It means at that distance the mist fully vanished because of great deal of warmth. Below 7cm only a lightweight coating is feasible. i.e. during this position only the fast paced mist particles can reach the glass substrate against the warmth waves generated by the furnace within the style of vapour. By trial it's optimized at 5 cm. i.e., within the 5cm distance only a smooth vapour reach is feasible to the substrate fully. Below 5 cm thanks to the fast movement of the mist, it's scattered by the substrate to outside.

Within the static position of this spray nozzle, the substrate size could also be 1cm x 1cm for coating. But here we used 2.5cm x 2.5cm substrate for coating. So, a small vertical and horizontal movement required for constant coating.

The droplets (mist) hit the substrate, where the solvent is entirely vaporized resulting in the deposition of a rough film during which the transmission decreases markedly. At the optimum air rate of flow the dimensions of the mist particle is additionally optimum. therefore, the thermal energy gained by the droplet is in such how that it vaporizes just above the substrate and provides a decent quality transparent film. within the case of high air flow the mist particle size are much smaller than the optimum size and also the droplet vaporizes entirely well above the substrate. Hence the homogeneous reaction takes place within the vapour space which diminishes the deposition efficiency and therefore the molecules condense as thermo crystallites. They form a powdery precipitate on the substrate leading to the decrease in transparency within the present work it's been observed that 3.5 kg/cm2 is that the optimum airflow rate which provides highly transparent, good quality films [17].

To optimize the compressor atmospheric pressure also by trail it absolutely was increased from 0.5 kg/cm3 to 4 kg/cm3. finally, it's found that below 2 kg/cm3 gas pressure the outflow of the chemical mist was very slow. Above 2 kg/cm3 only the chemical mist travelled vertically thanks to the pressure. At 3.5 kg/m3 only the graceful speed is achieved and it absolutely was reached to the substrate. Above 3.5 kg/m3 atmospheric pressure also suitable upto certain limit but it'll damage the tube and nebulizer. For the graceful coating, the optimized constant gas pressure is 3.5kg/cm3 (50 PSI).

A specially designed glass tube is employed as a carrier tube for the chemical mist generated by the Jet nebulizer. numerous tubes designed with various diameters and verified for the coating. within the lower diameter tubes the mist condensed again as liquid droplets and within the higher diameter tubes the speed of the mist is decreased. So finally, by trial we achieved a fine prime quality atomizing effect from the above-mentioned size tube. within the above tube the spray nozzle glass walls cross section should be pure flat structure. i.e. the 7mm nozzle outlet must be as an ideal circle. Then only the spray outlet are a stream lined. the warmth waves from the furnace may affect the mist coming through vertical tube. So, it may be arrested by using Teflon tape rounded on the vertical tube. a brand-new middle hole furnace is exclusively designed for this nebulizer spray with height of 30 cm and 10 cm hole diameter for better results, because during a long tube furnace, the warmth waves can arrest the mist before reach the substrate. The Jet nebulizer’s spray rate measured for the optimum carrier force per unit area of three.5 kg/m3. it's found that 0.75 ml/minute is that the normal rate. The deposition parameters, optimized by many trials [18] are: gas pressure = 3.5kg/cm2, nozzle to substrate distance = 5 cm, rate of spray = 0.75 ml/min. The ultrasonic type nebulizers are already used for skinny film coating for various chemical solutions and a few articles published for ultrasonic nebulizer thin film coating. this might be the primary time of this sort Jet nebulizer is employed for skinny film preparation. the subsequent are the benefits of Jet nebulizer spray pyrolysis over the traditional spray pyrolysis

(i) Relatively vasoconstrictor is enough to induce good oxide films.

(ii) For device fabrications, less heating effect required.

(iii) Additional accessories like purette etc., aren't required.

(iv) atiny low amount of precursor solution is required.

(v) It also reduced the material quantity.

(vi) Very small,compact and convenient to spray.

**Commercial Production and use of Nanoparticles**

The applications of nanoparticles where a little amount addition has been able to change substantially the properties and performance of the final product are becoming increasingly popular. A variety of such examples can be found in the area of functional coating [9].

**Application of Nano Materials**

Since nano materials possess unique beneficial chemical, physical and mechanical properties they will be used for a good form of applications. The applications include but aren't limited to the subsequent.

**Next generation computer chips**

The microelectronics industry has been emphasizing miniaturization, where by the circular like transistors, resistors and capacitors are reduced in size. By achieving a major reduction in their size, the microprocessor which contains these components can run much faster, thereby enabling computations at far greater speeds. However, there are several technological impediments to those advancements, including lack of the ultra-fine precursors to manufacture these components; poor dissipation of tremendous amount of warmth generated by these microprocessors, greater speeds, short time unit to failures [10].

**Better Insulation Materials**

Nanocrystalline materials synthesized by the combustion sol-gel technique leads to foam like structure called an aerogels. The porous aero gels are extremely light weight; yet, they'll withstand 100 times their weight. Aero gels are composed of three dimensional, continuous networks of particles with filled at their interstices. Since they're porous and air is trapped at their interstices, aero gels are currently getting used for insulation in offices, homes etc. By using aerogels for insulations heating and cooling bills are drastically reduced thereby saving power and reducing the attendant environmental pollution. they're also getting used as materials for smart windows, which darken when the sun is simply too bright and that they lighten themselves, when the sun isn't shining too brightly [11].

**High-sensitivity sensors**

Sensors employ their sensitively to the changes in various parameters they're designed to live. The measured parameters include electrical resistively, chemical activity, magnetic permeability, thermal conductivity and capacitance. of these parameters depend greatly on the microstructure of the materials employed within the sensors. The change within the sensors environment is manifested by the sensor material’s chemical, physical or mechanical characteristics are which suitably exploited for deduction. A reaction triggers a change within the sensor’s characteristics like conductivity and capacitance. the speed and also the extend of this reaction are greatly increased by a decrease within the grain size. Hence sensors made using nanocrystalline materials are extremely sensitive to the change within the environment. Typical applications for sensors made out of nanocrystalline materials are smoke detectors, ice detectors on air craft wings, engine performance sensors etc.

**Large electro chromic display devices**

The reaction governing electro chromism is that the double-injection of ions and electrons which combine with the nanocrystal. When the polarity is reversed, the color in bleached. The resolution, brightness and contrast of those devices greatly rely on the tungsten acid gel’s grain size. Hence, nano materials are being explored for this purpose [12] in a very larger way. it's also evident that nano materials out perform their conventional counter parts due to their superior chemical, physical and mechanical properties and their exception formability.

Many new applications are being discovered almost daily. They're much other applications and uses which are yet to be discovered. The nanomaterials of magnesium tin oxide belong to a category of wide band gap semiconductor material have shown reasonable performance in many fields like transparent electrodes for watch, solar cells etc.

**Cosmetics**

A vicinity of nanoparticle technology that has incredible commercial potential is that the cosmetic industry. Here there's an excellent demonstrated demand and also the technology is made simple, since the properties of color and lightweight fastness are achieved by component mixing within the cosmetic preparation. The massive markets for sunscreens and skin rejuvenation preparation promise additional revenues [13].

**Medical/Pharmacology**

Overall, much of the demand for nanoparticulate dispersions and coatings comes from the cosmetic and pharmaceutical industries particularly, liquid dispersion preparations are widely wont to apply topical coatings to the human epidermis because they'll be absorbed faster and more completely than conventional coatings [14].

**Micro electro mechanical systems**

Eventhough MEMS technologies will support the semiconductor industry particularly, there are many other applications being explored, like in medicine, ceramics, thin films, metal alloys and other proprietary applications.

**Printing**

Within the areas of image capture/image output addressed by ink jet technology nanoscience can help control the properties of the inks themselves.

**Semiconductors**

One style of bottom-up technology that's receiving considerable attention is thin film for the semiconductor industry.

**Biological applications**

Nanosized hydroxyapatite (HA) is that the most component of mineral bone. Living bone constantly undergoes a coupled resorptive-formative process remarked as bone remodeling. the method involves simultaneous bone removal and replacement through the respective activities of osteoblasts and osteoclasts, with the accompanying vascular supply and a network of canaliculi and lacunae. HA possesses exceptional biocompatibility and bioactivity properties with regard to bone cells and tissues, probably due to its similarity with the hard tissues of the body.

**For Hydrogen Production**

A recent study initiated that more deaths are caused by car emissions than by car accidents. [26]. Investigations also shown a considerable increase within the concentrations of carbon oxide and other greenhouse gases. Developing environmental concerns are advised to the extensive use of non-sustainable fossil fuels (oil, gas, and coal) and a continuing increasing of energy demand. Hydrogen could be a promising alternative fuel, since it's completely pollution free and might readily be produced from renewable energy resources, thus eliminating the mass production of greenhouse gases. Photocatalytic hydrogen production from water is one in all the promising techniques because it's supported photon (or solar) energy, which could be a clean, perpetual source of energy, and mainly water, which may be a natural resource finally it is an environmentally safe technology. The photochemical conversion of solar power into a storable kind of energy, i.e. hydrogen, allows one to house the intermittent character and seasonal variation of the solar influx. However, it requires a photocatalyst that ought to possess chemical stability, corrosion resistance, actinic radiation harvesting and suitable band edges.

**Conclusion**

Semiconductor nanomaterials are advanced materials for various applications which are discussed at length. The unique physical and chemical properties of semiconductor nanomaterial make it suitable for application in emerging technologies, like nano electronics, nanophotonics, energy conversion, non-linear optics, miniaturized sensors and imaging devices, solar cells, detectors, photography and bio-medicine. There are three key steps: materials preparation, properties, characterization and devices fabrication. Moreover, the pollution free alternate fuel can be generated by the way of this nano science and technology

References

[1]. Slimonis F. Faber A.J and Hoogendom C.J, Porcelain enamel ledabsorbens, coated by spectra tin oxide, J. Sol. Eng 23 (1987), 109

[2]. Wheat CRC Hand Book of +chemistry and physics 65th edition, CRC press Bocaration (1985)

[3]. Nathail Hall, Dictionary of metal finishing chemicals, Ch Eng, Metals and plastics, (1963), 82

[4]. Wang, Zhong Lin, and XiangdongFeng, Polyhedral shapes of CeO2nanoparticles, The Journal of Physical Chemistry B107, no. 49 (2003),13563

[5]. Zhang, F.; Chan, S.-W.; Spanier, J.E.; Apak, E.; Jin, Q.; Robinson, R.D.; Herman, I.P,Cerium oxide nanoparticles: Size-selective formation and structure analysis,Appl. Phys. Lett. 80, (2002), 127

[6]. Adachi, G.; Masui, T, In Catalysis by Ceria and Related Materials; Trovarelli, A. (Editor); Imperial College Press: London, (2002), Chapter 3

[7]. Rodriguez, J.A.; Wang, X.; Hanson, J.C.; Liu, G.; Iglesias-Juez, A.; FernándezGarcía, The behavior of mixed-metal oxides: Structural and electronic properties of Ce1−xCa*x*O2 and Ce1−xCa*x*O2−x, M. J. Chem. Phys., 119, (2003), 5659

[8]. Kossoy, a.; Feldman, Y.; Wachtel, E.; Gatsman, K.; Lubomirsky, L.; Fleig, J.; Meier, J.; Metal Oxide Nanoparticles,Phys. Chem. Chem. Phys., 8, (2006), 111

[9]. Shelef, M.; Graham, G.W., Why rhodium in automotive three way catalysts? Catal. Rev. –Sci. Eng., 36, (1994), 433

[10]. Trovarelli, A,Catalytic properties of Ceria and CeO2 containing materials, Catal. Rev. Sci., Eng., 38, (1996), 439

[11]. Martínez-Arias, A.; Fernández-García, M.; Ballesteros, V.; Salamanca, L.N.; Conesa, J.C.; Otero, C.; Soria, J. Langmuir,Metal oxide Nanoparticles, 15, (1999), 4797

[12]. Rochford, Jonathan, and Elena Galoppini., Zinc(II) Tetraarylporphyrins Anchored to TiO2, ZnO, and ZrO2 Nanoparticle Films through Rigid-Rod Linkers*,*Langmuir 24, no.10 (2008): 5366

[13]. Verma, Sandeep, PrasenjitKar, Amitava Das, Dipak K. Palit, and Hirendra N. Ghosh, Interfacial Electron-Transfer Dynamics on TiO2 and ZrO2 Nanoparticle Surface Sensitized by New Catechol Derivatives of Os(II)-polypyridyl Complexes:  Monitoring by Charge-Transfer Emission,The Journal of Physical Chemistry C 112, 8 ,(2008): 2918

[14]. Kim, Hyung Hwan, Jong Bo Park, Min Ji Kang, and Young Hwan, Surface-modified silk hydrogel containing hydroxyapatitenanoparticle with hyaluronic acid–dopamine conjugate, Park. International journal of biological macromolecules 70, (2014): 516

[15]. Meena, Ramovatar, Kavindra Kumar Kesari, MadhuRani, and R. Paulraj, Effects of hydroxyapatite nanoparticles on proliferation and apoptosis of human breast cancer cells (MCF-7), Journal of Nanoparticle Research 14, 2, (2012),712

[16] Shanti S, Subramanian C, Ramasamy P, Metal sulfide thin films by chemical spray pyrolysis, Materials science and Engineering , B57,(1999) 127

[17]. Shen-ChihShen, Yu-Jen Wang, Yung-Yue Chen., Design and fabrication of medical micro-nebulizer, Sensors and Actuators: Physical 144(1), (2008), 135

[18]. Manoj P.K, Gopchandran K.G, Peter koshy,.Vaidyan,Benny Joseph V.K,Growth and characterization of indium oxide thin films prepared by spray pyrolysis, Opt. Mater. 28,(2006), 1405

[19] Wu, Hsi-Chin, Tzu-Wei Wang, Jui-Sheng Sun, Wen-Hsi Wang, and Feng-Huei Lin, A novel biomagnetic nanoparticle based on hydroxyapatite,Nanotechnology 18, 16, (2007), 165601.

[20]. Fujii, Syuji, Yuki Miyanari, Taiki Nishimura, Yuichi Yokoyama, ShoHamasaki, Masahiro Okada, Tsutomu Furuzono, Shojiro Matsuda, Hideki Takamori, and Yoshinobu Nakamura, In vitrodegradation of hydroxyapatitenanoparticle-coated biodegradable microspheres, Polymer degradation and stability 98, 1, (2013), 377

[21]. Hu, Yang, ShengwenZou, Weike Chen, Zhen Tong, and Chaoyang Wang,Mineralization and drug release of hydroxyapatite/poly(l-lactic acid) nanocomposite scaffolds prepared by Pickering emulsion templating, Colloids and Surfaces B: Biointerfaces ,122, (2014), 559

[22]. Nie, Hemin, and Chi-Hwa Wang, Fabrication and characterization of PLGA/HAp composite scaffolds for delivery of BMP-2 plasmid DNA, Journal of controlled release 120, (2007), 111, 1

[23] Fujii, Syuji, Masahiro Okada, Taiki Nishimura, Hayata Maeda, Tatsuya Sugimoto, Hiroyuki Hamasaki, Tsutomu Furuzono, and Yoshinobu Nakamura, Hydroxyapatite-armored poly(ε-caprolactone) microspheres and hydroxyapatite microcapsules fabricated via a Pickering emulsion route,Journal of colloid and interface science , 374, (2012), 1, 1

[24] JiHoon Lee, II Tae Kim, RinaTannenbaum, MeishaL.Shofner, Synthesis of polymer-decorated hydroxyapatite nanoparticles with a dispersed copolymer template, J.Mater.Chem., 22, (2012),11556

[25] L.Mohan, D.Durgalakshmi, M.Geetha, T.S.N.Sankaranarayanan, R.Asokamani, Electrophoretic deposition of nanocomposite (HAp+TiO2) on titanium alloy for biomedical applications, ceramics international, 38, (2012),3435

[26] FaheemA.Sheikh, Muzafar A. Kanjwal, Hak Yong Kim, Hern Kim, Fabrication of Titanium dioxide nanofibers containing hydroxyapatitenanoparticles, Appl. Surf. Sci., 257, (2010), 296

[27] Hsien-Te Chen, Chi-Jen Chung, Tsai-Ching Yang, Chin-Hsin Tang, Ju-Liang He, Microscopic observations of osteoblast growth on micro-arc oxidized β titanium, Appl. Surf. Sci. 266, (2013), 73

[28] Kaviyarasu, K., Mariappan, A., Neyvasagam, K., Ayeshamariam, A., Pandi, P., Palanichamy, R.R., Gopinathan, C., Mola, G.T. and Maaza, M. Photocatalytic performance and antimicrobial activities of HAp-TiO2nanocomposite thin films by sol-gel method, Surfaces and Interfaces, 6(2017), pp.247

[29] Hu, Z., Haneklaus, S., Sparovek, G. &Schnug, E. Rare earth elements in soils. Commun. Soil Sci. Plant. Anal. **37**, 1381–1420 (2006).

[30] Bouzigues, C., Gacoin, T. &Alexandrou, A. Biological applications of rare-earth based nanoparticles. Acs Nano **5**, 8488–8505 (2011).