# A Review Paper on Role of Nano-Structured Materials in Mechanical Engineering Applications

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***Abstract*** *Here we shall discuss the role of Nano-structured materials in mechanical engineering applications. In these studies, the application in the field of Automobile Industry, Construction, and Energy are investigated. These studies are important for understanding Properties Considered for mechanical applications. The drawbacks in using Nano materials are also came under this study.*

**Keyword—***Nanostructured Materials, Bottom-Up and Top-down approaches, Nano crystalline ceramics, Chassis.*

## I. Introduction

A material in which one of its dimension is below 100 nm (nanometre) is defined as Nano material or Nano-structured materials. Exponential growth of Nanotechnology has enabled a great variety of products already reach the market. Nano products are there in the field of engineering, medical, chemical, agribusiness, electronics, defence .etc. Nano material products are ranging from computer chips to aircraft wings, fuel cells and even artificial organs.

## II. Nano structured materials

A material in which one of its dimension is below 100 nm (nanometre) is defined as Nano material or Nano-structured materials. . Materials with structure at the Nano scale often have unique optical, electronic, or mechanical properties. (Size 10 & Normal)An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

### A. Natural Nano materials

Biological systems often feature natural, functional nanomaterial. The structure of foraminifera (mainly chalk) and viruses (protein, capsid), the wax crystals covering a lotus or nasturtium leaf, spider and spider-mite silk, the blue hue of tarantulas, the "spatula" on the bottom of gecko feet, some butterfly wing scales, natural colloids (milk, blood), horny materials (skin, claws, beaks, feathers, horns, hair), paper, cotton, nacre, corals, and even our own bone matrix are all natural organic nanomaterial.

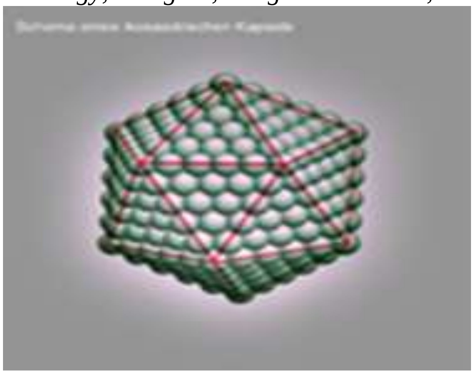

Fig.1 Viral capsid

Fig. 2

"Lotus effect", hydrophobic effect with self-cleaning ability

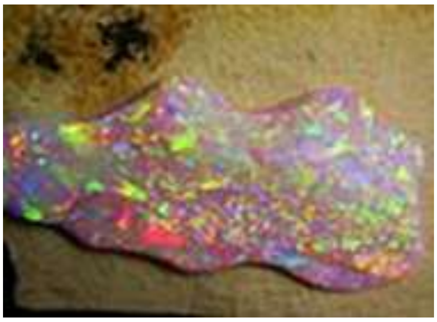

Fig.3

Brazilian Crystal Opal. The play of colour is caused by the interference and diffraction of light between silica spheres (150 - 300 nm in diameter).

### B. Inorganic Nano materials

Inorganic Nano materials, (e.g. quantum dots, nanowires and Nano rods) because of their interesting optical and electrical properties, could be used in optoelectronics. Furthermore, the optical and electronic properties of Nano materials which depend on their size and shape can be tuned via synthetic techniques.

## III. HISTORY OF NANO MATERIALS

The history of Nano materials began immediately after the big bang when Nanostructures were formed in the early meteorites. Nature later evolved many other Nanostructures like seashells, skeletons etc. One of the first scientific report is the colloidal gold particles synthesized by Michael Faraday as early as 1857. Nanostructured catalysts have also been investigated for over 70 years. By the early 1940's, precipitated and fumed silica nanoparticles were being manufactured and sold in USA and Germany as substitutes for ultrafine carbon black for rubber reinforcements.

## IV. PROPERTIES OF NANO MATERIALS

Nanoparticles are of great scientific interest as they are effectively a bridge between bulk materials and atomic or molecular structures. A bulk material should have constant physical properties regardless of its size, but at the Nano-scale this is often not the case. Size-dependent properties are observed such as quantum confinement in semiconductor particles, surface Plasmon resonance in some metal particles and super Para magnetism in magnetic materials.

Nanoparticles exhibit a number of special properties relative to bulk material. Copper nanoparticles smaller than 50 nm are considered super hard materials that do not exhibit the same malleability and ductility as bulk copper.

The often very high surface area to volume ratio of nanoparticles provides a tremendous driving force for diffusion, especially at elevated temperatures. Sintering is possible at lower temperatures and over shorter durations than for larger particles. This theoretically does not affect the density of the final product, though flow difficulties and the tendency of nanoparticles to agglomerate do complicate matters.

They also offer good physical & mechanical properties in Nano structure and lightweight. Porosity is an important property for Nano materials.

## V. SYNTHESIS OF NANO MATERIALS

The goal of any synthetic method for Nano materials is to yield a material that exhibits properties that are a result of their characteristic length scale being in the Nano meter range (~1 – 100 nm).

Accordingly, the synthetic method should exhibit control of size in this range so that one property or another can be attained. Often the methods are divided into two main types "Bottom Up" and "Top Down."

In bottom-up approach the clusters of atoms are adhere together to make a Nano material. While in top-down approach the bulk material is divided till it became a Nano structure material

### *A. Bottom Up*

Bottom up methods involve the assembly of atoms or molecules into nanostructured arrays. In these methods the raw material sources can be in the form of gases, liquids or solids. The latter requiring some sort of disassembly prior to their incorporation onto a nanostructure. Bottom methods generally fall into two categories: chaotic and controlled. Bottom-up approach uses the techniques of molecular synthesis, colloid chemistry, polymer science, and related areas to make structures with nanometre dimensions.

### *B. Top Down*

Knowledge of processes for bottom-up assembly of structures remains in their infancy in comparison to traditional manufacturing techniques. As a result, the most mature products of nanotechnology (such as modern CPUs) rely heavily on top-down processes to define structures. The traditional example of a top-down technique for fabrication is lithography in which instruments (such as a modern stepper) are used to scale a macroscopic plan to the Nano scale.

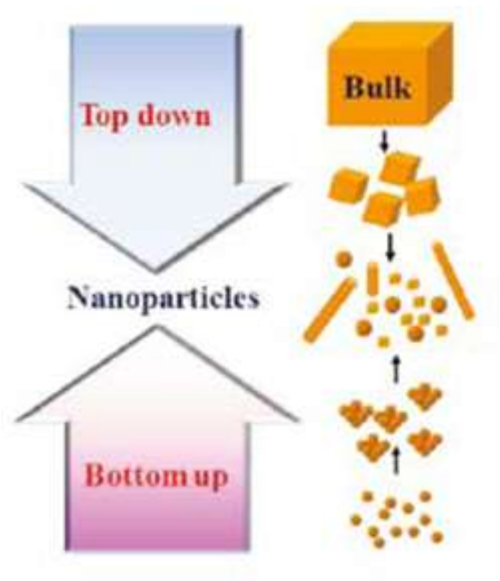


Fig. 4Top down and bottom up approach

## VI. APPLICATION OF NANO MATERIALS

### *A. Application in automobile industry*

#### *1. Spark plug*

Since Nano materials are stronger, harder, and resist wear and erosion, they are currently being considered for use in spark plugs. Nano electrodes would make spark plugs long lasting and fuel-efficient. The rail plug made by Nano material creates powerful sparks that burn fuel better.

### 2. Engine coatings

Automobiles waste huge amounts of energy by way of heat loss from the engine, especially from the diesel ones. Engineers are currently looking at coating engine cylinders with Nano crystalline ceramics, like zirconia and alumina, to help preserve heat efficiency and increase fuel combustion. Engineers are currently looking at coating engine cylinders with Nano crystalline ceramics, like zirconia and alumina, to help preserve heat efficiency and increase fuel combustion.

### 3. Engine

Today's car engines are only 25 per cent efficient; meaning only a quarter of the energy stored in fuel is actually converted to useful work. Fuel cells - devices that work by harnessing the chemical attraction between oxygen and hydrogen to produce electricity - are, by contrast, 50 per cent efficient. Further, because they use oxygen - which is taken from the air, and hydrogen - the most abundant element in the universe, they have the potential to produce clean and cheap energy. The only by-products are heat and water.

### 4. Braking system, Body panel

Use of aluminium nanotube composite in the braking system results effective braking performance. It will reduce brake system weight while increasing acceleration. In addition to being lighter, Nano composites are significantly more resistant to wear and tear in case of body panels.

### 5. Chassis

Chassis are structural support of a vehicle. If we can reduce its weight it will become more fuel efficient. So we can use Nano size steel instead of Aluminium. It will offer lower weight, dimensional accuracy, corrosion resistance and aesthetics.

## B. Application in the Field Of Energy

### 1. Batteries

With the growth in portable electronic equipment (mobile phones, laptop computers), there is great demand for lightweight, high- energy density batteries. Nickel–metal hydride batteries made of Nano crystalline nickel and metal hydrides are requiring less frequent recharging and to last longer because of their large surface area. Nanoparticle matrices in battery electrodes can drastically increase their ability to store lithium ions, increasing the storage density of the battery.

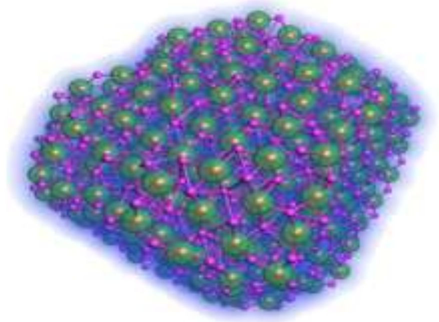

Fig. 5 Lithium ions in a battery

The high-rate discharge capability of the Nano materials has also been demonstrated in prototype cells for the $Li_4Ti_5O_{12}$ materials. Emerging applications have steered Lithium-ion materials R&D in a new direction, which includes development of nanomaterial electrodes. , Lithium-ion Nano materials can also be expected to appear in automotive applications like PHEV and also in battery electrical energy storage systems.

### 2. Solar Panels

Nanotechnology could help increase the efficiency of light conversion by using nanostructures. Conventional semiconductors manage to use 40% of the Sun's energy. Nano materials help in reducing materials and process rates, energy saving and enhanced renewable energy sources

## C. Application in the field of construction

Steel has been widely available material and has a major role in the construction industry. The theoretical strength of steel is 27.30 GPa (in <111> direction). There are two ways of achieving high strength in steels. One method is by reducing the size of a crystal to such an extent that it is free of any defects. Second method is by introducing a very large density of defects in a metal sample that act as an obstacle to the motion of dislocations.

The Nano size steel produce stronger steel cables which can be used in bridge construction. The strengthening arises due to the presence of Nano scale cementite/ferrite lamellar structure. The high carbon steel wire is an important engineering material used for reinforcing automobile tires, galvanized wires etc.

Fig. 6 Nano steel structured building

### *1. Steel*

Steel is a widely available material that has a major role in the construction industry. The use of nanotechnology in steel helps to improve the physical properties of steel. Fatigue, or the structural failure of steel, is due to cyclic loading. Current steel designs are based on the reduction in the allowable stress, service life or regular inspection regime. This has a significant impact on the life-cycle costs of structures and limits the effective use of resources. Advancements in this technology through the use of nanoparticles would lead to increased safety, less need for regular inspection, and more efficient materials free from fatigue issues for construction.

Steel cables can be strengthened using carbon nanotubes. Stronger cables reduce the costs and period of construction, especially in suspension bridges, as the cables are run from end to end of the span.

The use of vanadium and molybdenum nanoparticles improves the delayed fracture problems associated with high strength bolts. This reduces the effects of hydrogen embrittlement and improves steel micro-structure by reducing the effects of the inter-granular cementite phase.

### *2. Glass*

Research is being carried out on the application of nanotechnology to glass, another important material in construction. Titanium dioxide ($TiO_2$) nanoparticles are used to coat glazing since it has sterilizing and anti-fouling properties. The particles catalyse powerful reactions that break down organic pollutants, volatile organic compounds and bacterial membranes. $TiO_2$ is hydrophilic (attraction to water), which can attract rain drops that then wash off the dirt particles. Thus the introduction of nanotechnology in the Glass industry incorporates the self-cleaning property of glass.

## VII. EFFECT OF NANO MATERIALS ON HUMAN IN CONSTRUCTION FIELD

1. Effect of nanoparticles on health and environment: Nanoparticles may also enter the body if building water supplies are filtered through commercially available Nano filters. Airborne and waterborne nanoparticles enter from building ventilation and wastewater systems.
2. Effect of nanoparticles on societal issues: As sensors become commonplace, a loss of privacy and autonomy may result from users interacting with increasingly intelligent building components.

## VIII. DISADVANTAGES OF NANO MATERIALS

- The nanostructured steels exhibit inadequate ductility.
- Instability of the particles - Retaining the active metal nanoparticles is highly Challenging, as the kinetics associated with Nano materials is rapid.
- Nanostructured materials require non-traditional processing. It will lead to high cost.
- Impurity - Because nanoparticles are highly reactive, they inherently interact with impurities as well.
- The workers who engaged in the production can cause health hazard.
- Biologically harmful – Nano materials are usually considered harmful as they become transparent to the cell-dermis. Toxicity of Nano materials also appears predominant owing to their high surface area and enhanced surface activity.
- Fine metal particles act as strong explosives owing to their high surface area coming In direct contact with oxygen and due to this exothermic combustion can cause Explosion.
- Recycling and disposal - There are no hard-and-fast safe disposal policies evolved for Nano materials. Issues of their toxicity are still under question

## IX. SAFETY OF NANO MATERIALS

Nanoparticles behave differently than other similarly sized particles. It is therefore necessary to develop specialized approaches to testing and monitoring their effects on human health and on the environment.

When materials are made as nanoparticles, their surface area to volume ratio will be more. The greater specific surface area (surface area per unit weight) may lead to increased rate of absorption through the skin, lungs, or digestive tract and may cause unwanted effects to the lungs as well as other organs. However, the particles must be absorbed in sufficient quantities in order to pose health risks.

The result of a study in 2008 showed that iron oxide nanoparticles caused little DNA damage and were non-toxic. Zinc oxide nanoparticles were slightly worse. Titanium dioxide caused only DNA damage. Carbon nanotubes caused DNA damage at low levels. Copper oxide was found to be the worst offender, and was the only nanomaterial identified by the researchers as a clear health risk.

Though Nano materials are not confirmed as a health risk to workers who produce them, NIOSH recommends that exposure precautions and personal protective equipment be used to protect workers until the risks of nanomaterial manufacture are better understood.

## X. Conclusions

This technical seminar will help in knowing about Nano materials and its vast applications. By doing this seminar I come across some conclusions. Nano technology is a vast field. It is contributing its properties to countless fields. The fundamental properties of Nano particles are in turn result in their special functions. The science world not blindly using it because yet it is not proved fully safe. Nano structured materials will be our future materials.

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