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Nanotechnology – Emergence in Automotive Industry

Abstract

Since its emergence, Nanotechnology is steadily growing in its importance in the scientific world.

It offers highly flexible solutions to complex problems in a wide range of research areas such as Medicine, Electronics, Food, Fuel Cell, Space, Energy, Sensors, Fabrics, Automobiles and many more.

Various factors are helping the Nanotechnology to grow in its size such as research funding, government support and private sector funding and drive for miniaturization. By 2024, Nanotechnology market is expected to cross US$ 125 Billion mark.

This study is an attempt to understand the future on Nanotechnology, its relationship and impact to automotive industry in particular.

Introduction

Nanotechnology is manipulation of matter on an atomic, molecular, and supra-molecular scale. The earliest, widespread description of nanotechnology referred to the particular technological goal of precisely manipulating atoms and molecules for fabrication of macroscale products, also now referred to as molecular nanotechnology. National Nanotechnology Initiative, defines nanotechnology as the manipulation of matter with at least one dimension sized from 1 to 100 nanometers.

Scientists currently debate the future implications of nanotechnology. Nanotechnology may be able to create many new materials and devices with a vast range of applications, such as in nano medicine,nano electronics, biomaterials production, and consumer products. On the other hand, nanotechnology raises many of the same issues as any new technology, including concerns about the toxicity and environmental impact of nanomaterials, and their potential effects on global economics, as well as speculation about various doomsday scenarios. These concerns have led to a debate among advocacy groups and governments on whether special regulation of nanotechnology is warranted.

Owing to small sizes and extremely large specific surface areas of the nanoparticles, Nanotechnology has found substantial applications in the form of nano-fluids.

Nano-fluids have better thermal conductivity, ability to flow through miniature passage without clogging, long-term stability, and homogeneity. These fluids have found its applications predominantly in automotive and nuclear areas.

Here is an example of enhanced Thermal Conductivity with ZnO Nanoparticles in different proportion added to a fluid.

It can be observed that the thermal conductivity ratio increases as the particle volume fraction increases.

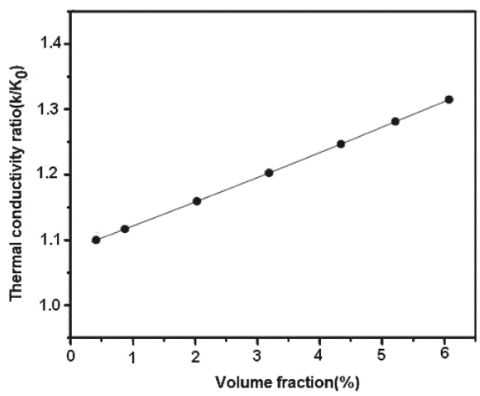

Fig. 1 Thermal conductivity as a function of ZnO volume fraction

On the other hand, Nanomaterials are substances which are produced through a well-designed fabrication process. These are classified as

- carbon-based
- metal-based
- dendrimers
- composites

Nanomaterials can be characterized by a variety of scattering techniques. The simplest, most direct method is x-ray scattering, which can be used to investigate the phase and particle size.

Nanomaterials can be classified as per the size and dimensions as below :

1.*Zero-dimensional*: where (0D) all three dimensions of materials exist in nanoscale with NPs typically in spherical size of dia 1-50 nm.. NPs can be spherical in size with a diameter of 1–50 nm.

Examples - gold, palladium, platinum, silver or quantum dots.

2.*One-dimensional*: have one dimension are in the range of 1–100 nm and the other two dimensions can be in macroscale. Nanowires, nanofibers, nanorods, and nanotubes are examples of one-dimensional (1D) nanomaterials. Some metals (Au, Ag, Si, etc.), metal oxides (ZnO, TiO_2, CeO_2, etc.), quantum dots, and others can provide 1D nanostructures.

3.*Two-dimensional*: here two dimensions are in nanoscale and one dimension is in macroscale. Nano thin-films, thin-film multilayers, nanosheets, or nanowalls are two-dimensional (2D) nanomaterials. The area of 2D nanomaterials can be several square micrometers keeping thickness always in the nanoscale range.

4.*Three-dimensional*: In (3D) there are no dimensions in nanoscale, and all dimensions are in macroscale. Bulk materials are 3D nanomaterials that are composed of individual blocks which may be in nanometer scale (1–100 nm) or more.

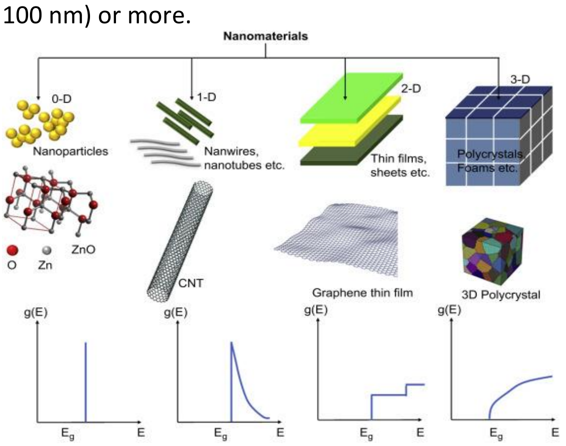

Fig. 2 Schematic representation of zero-dimensional (0D), one-dimensional (1D), two-dimensional (2D), and three-dimensional (3D) nanomaterials and density of electron states of a semiconductor by varying dimension, where g(E) is the density of states.

Nanotechnology and its applications is a complex topic and it is evolving every day.
However, an attempt has been made to establish relationship of Nanotechnology and other fundamental sciences.

For this purpose basically 4 categories of fundamental sciences are considered:

1. Bio
2. Neuro
3. Digital
4. Green

The **Digital Revolution**, also known as the **Third Industrial Revolution**, is probably most talked about evolution due to its fast commercialization that has shifted mechanical and analogue world to the digital electronics. This has led to Industrial Revolution in the Automotive World with beginning of the Information Age.

Nano-science has found its space in Digital Science in a variety of ways such as quantum dot television and optical metamaterial checking. It is presumed the biggest impact of Nanotechnology in Digital world will come through miniaturization, new materials such as Graphene, *Polarotronics* and Optical computing. This will find enormous application in automotive applications as stated later in this article.

Environmental technology also referred to as green technology is the application of one or more of environmental science, green chemistry, environmental monitoring and electronic devices to monitor, model and conserve the natural environment and resources. This is probably the most talked about topic at global level to curb the negative impacts of human involvement. Nano-technology has found its space here too in making a positive contribution in the areas of paints and plastics. The intensity of research in area of energy such as methanol fuel cell, rapid battery cooling and solar heat absorption is going to change the dynamics of mobility industry and disparity in energy availability. Way forward, it may help to develop room temperature super conductors which will enormously help to solve the energy problems, develop faster computers and unimaginable memory storages devices.

Assessment of Nanotechnology and its Penetration into Automotive Applications

Automotive industry is on growth path and in-spite of several external threats, it will continue to grow. Automotive industry has been one of the prime drivers of all new technologies due to highly demanding requirements on materials, software technology and safety standards. Tighter emission standards has forced the industry to continuously change the course of technology it followed from decade to decade since its invention about 100 years ago.

Starting with the use of steam initially, it moved to fossil fuel and later much cleaner types of fuels reducing its impact on emission and carbon foot print.

However, with successful use of liquefied fossil fuels for over 100 years, it seems the emergence of battery technology is slowly replacing the fossil fuels. Trend of using more and more renewable energy and societal pressure on cleaner environment is forcing auto-makers to look for alternatives that will have lower impact to the carbon foot print in the future.

Fuel cells are regarded as the power plants of the future. It will consume hydrogen which has zero impact to emission.

Nanotechnology offers its one the biggest opportunities in the automotive world. The automotive sector is a major consumer of material technologies and nanotechnologies promise to improve the performance of existing technologies significantly. Applications range from already existing – paint quality, fuel cells, batteries, wear-resistant tires, lighter but stronger materials, ultra-thin anti-glare layers for windows and mirrors – to the futuristic – energy-harvesting bodywork, fully self-repairing paint, switchable colours, shape-shifting skin to the sensors will play a major role in the car industry.

The basic trends that nanotechnology enables for the automobile are

- Lighter and stronger materials
- Catalysts, fuel additives, lubricants
- Hydrogen and fuel cell-powered cars
- Miniaturized electronic systems
- Self healing paints
- *Spintronics* offers a paradigm shift in the Sensor technology.

With the use of nanoscaled magnetic materials, *Spintronics* or electronic devices when switched off will not have a stand-by power dissipation problem. With this advantage, devices with much lower power consumption, known as non-volatile electronics can become a reality.

In the long run ultra-light weight bendable batteries could become reality creating a new disruption in the automotive evolution,

Conclusion

The future of mobility is expected to get disrupted with the availability newer materials – thanks to research activity supported for the Nanotechnology worldwide. Automotive industry will see more of Nano applications starting from tyres, power train, battery and energy management, electronics, filtration, interior comfort, coating, light weighting and several other sub-systems.

A pictorial representation in Fig. 3 below indicates Nano-technology and its broad areas of automotive applications. This may help to understand the Nano-technology and its possible penetration in the automotive applications.

Nanomaterials/ Nanoparticles, Nanolithography and Nanotools are commercially highly successful initiatives. With the emergence of Electric Vehicles, (EV) Nanotechnology is expected to make significant contribution to the automotive world in a positive way.

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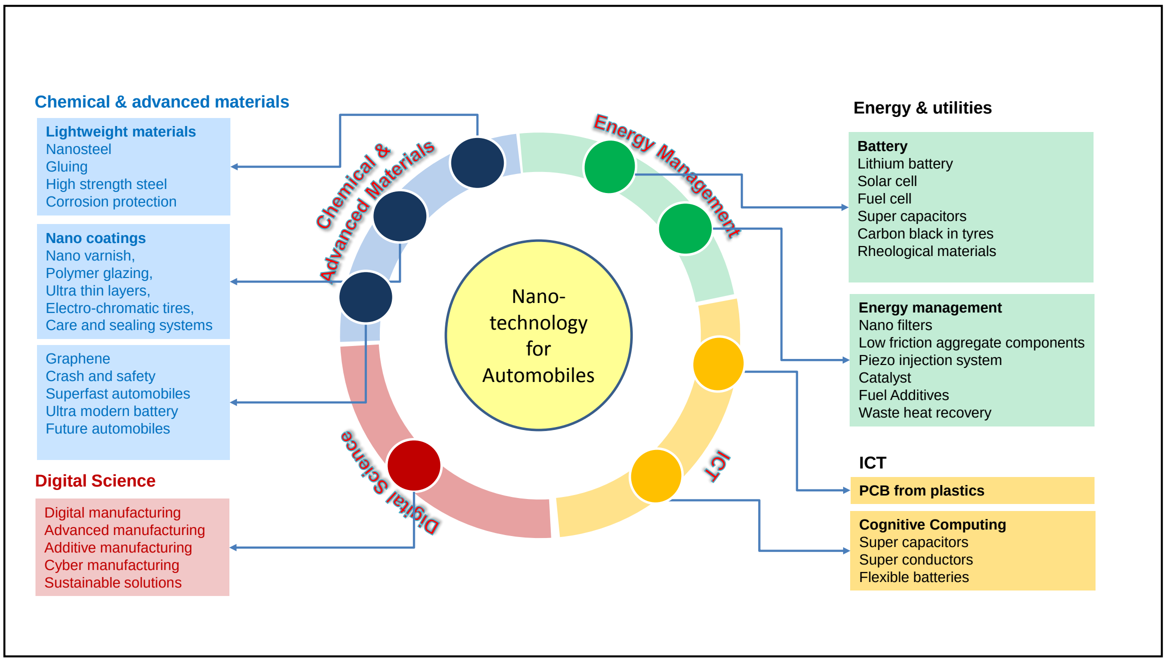

Fig. 3 Nanotechnology – Authors perspective in matured state