Nanotechnologies - Overview & Applications

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Abstract

Nanotechnology is the study or application of any matter or knowledge at the 1-100 nanometer scale. Nano-development could benefit human health, environmental remediation methods, technology and many other fields. Because the emerging, cross-disciplinary field of nanotechnology incorporates chemistry, biology, and other such materials and physical sciences, medicine and engineering, one identified issue of nano-development is the challenge of successful communication among researchers of diverse disciplinary backgrounds.

A Nanotechnology is the study manipulation and manufacture of extremely tiny machines or devices. These devices are so small to the point of manipulating the atoms themselves to form materials. By this Nanotechnology we can make computers billions of times more powerful than today's computers, and new medical capabilities that will heal and cure in some cases will then make to cure in every case of diseases.

1. Introduction

Nanotechnology is a part of science and technology about the control of matter on the atomic and molecular scale - this means things that are about 100 nanometers or smaller. Nanotechnology includes making products that use parts this small, such as electronic devices, catalysts, and sensors etc. Nanotechnology is defined as the study of structures between 1 nanometer and 100 nanometers in size.

Nanotechnology brings together scientists and engineers from many different subjects, such as applied physics, materials science, interface and colloid science, device physics, chemistry, self-replicating machines and robotics, chemical engineering, mechanical engineering, biology, biological engineering, and electrical engineering

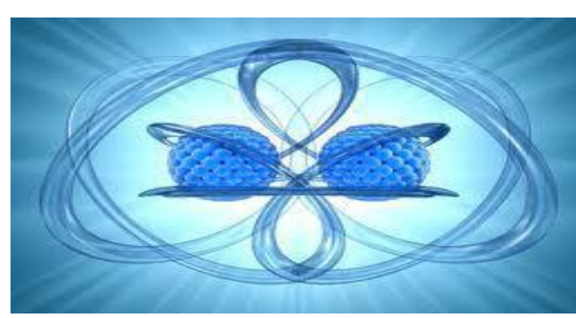

Figure-1 Nanotechnology.

2. The Beginning of Nanotechnology.

The history of nanotechnology traces the development of the concepts and experimental work falling under the broad category of nanotechnology. Although nanotechnology is a relatively recent development in scientific research, the development of its central concepts happened over a longer period of time. The emergence of nanotechnology in the 1980s was caused by the convergence of experimental advances such as the invention of the scanning tunneling microscope in 1981 and the discovery of fullerenes in 1985, with the elucidation and popularization of a conceptual framework for the goals of nanotechnology beginning with the 1986 publication of the book Engines of Creation.

3. Overview of Nanotechnology.

Nanotechnology is highly interdisciplinary, involving physics, chemistry, biology, materials science, and the full range of the engineering disciplines. The word nanotechnology is widely used as shorthand to refer to both the science and the technology of this emerging field. Narrowly defined, Nano science concerns a basic understanding of physical, chemical, and biological properties on atomic and near-atomic scales. Nanotechnology, narrowly defined, employs controlled manipulation of these properties to create materials and functional systems with unique capabilities.

There are two principal reasons for qualitative differences in material behavior at the Nano scale.

First, quantum mechanical effects come into play at very small dimensions and lead to new physics and chemistry.

Second, a defining feature at the Nano scale is the very large surface-to-volume ratio of these structures.

This means that no atom is very far from a surface or interface, and the behavior of atoms at these higher-energy sites have a significant influence on the properties of the material. For example, the reactivity of a metal catalyst particle generally increases appreciably as its size is reduced—macroscopic gold is chemically inert, whereas at Nano scales gold becomes extremely reactive and catalytic and even melts at a lower temperature. Thus, at Nano scale dimensions material properties depend on and change with size, as well as composition and structure.

4. Working of Nanotechnology.

In order to understand the unusual world of nanotechnology, we need to get an idea of the units of measure involved. A centimeter is one-hundredth of a meter, a millimeter is one-thousandth of a meter, and a micrometer is one-millionth of a meter, but all of these are still huge compared to the Nano scale. A **nanometer (nm)** is one-billionth of a meter, smaller than the As small as a nanometer is, it's still large compared to the atomic scale. An atom has a diameter of about 0.1 nm. An atom's nucleus is much smaller -- about 0.00001 nm. Atoms are the building blocks for all matter in our universe. You and everything around you are made of atoms. Nature has perfected the science of manufacturing matter molecularly. For instance, our bodies are assembled in a specific manner from millions of living cells. Cells are nature's Nano machines. At the atomic scale, elements are at their most basic Level. On the Nano scale, we can potentially put these atoms together to make almost anything.

5. Applications of Nanotechnology:

With nanotechnology, a large set of materials and improved products rely on a change in the physical properties when the feature sizes are shrunk. Nanoparticles, for example, take advantage of their dramatically increased surface area to volume ratio.
There are numerous applications of nanotechnology which are shown in following figure:

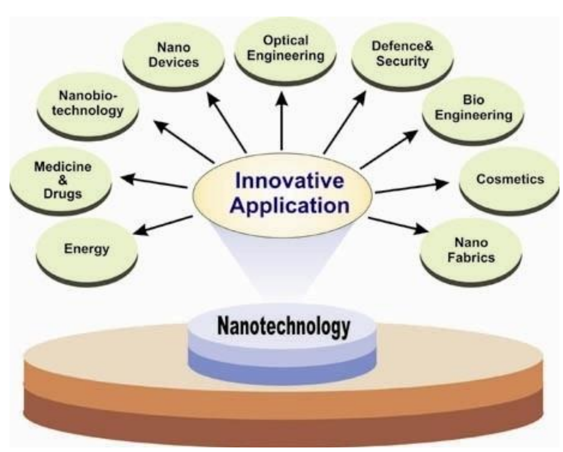

Figure-2 Applications of Nanotechnology.

5.1 Nanotechnology in Medicines:

The biological and medical research communities have exploited the unique properties of nanomaterials for various applications (e.g., contrast agents for cell imaging and therapeutics for treating cancer). Terms such as biomedical nanotechnology, nanobiotechnology, and nanomedicine are used to describe this hybrid field. Functionalities can be added to nanomaterials by interfacing them with biological molecules or structures. The size of nanomaterials is similar to that of most biological molecules and structures; therefore, nanomaterials can be useful for both in vivo and in vitro biomedical research and applications. Thus far, the integration of nanomaterials with biology has led to the development of diagnostic devices, contrast agents, analytical tools, physical therapy applications, and drug delivery vehicles.
Nanotechnology-on-a-chip is one more dimension of lab-on-a-chip technology. Magnetic nanoparticles, bound to a suitable antibody, are used to label specific molecules, structures or microorganisms. Gold nanoparticles tagged with short segments of DNA can be used for detection of genetic sequence in a sample. Multicolor optical coding for biological assays has been achieved by embedding different-sized quantum dots into polymeric micro beads. Nano pore technology for analysis of nucleic acids converts strings of nucleotides directly into electronic signatures.

5.1.1. Drug Delivery: Nanotechnology has been a boon for the medical field by delivering drugs to specific cells using nanoparticles. The overall drug consumption and side-effects can be lowered significantly by depositing the active agent in the morbid region only and in no higher dose than needed. This highly selective approach reduces costs and human suffering.

5.1.2. Tissue engineering:
Nanotechnology can help reproduce or repair damaged tissue. ―Tissue engineering‖ makes use of artificially stimulated cell proliferation by using suitable nonmaterial-based scaffolds and growth factors. For example, bones can be regrown on carbon nanotube scaffolds. Tissue engineering might replace today's conventional treatments like organ transplants or artificial implants. Advanced forms of tissue engineering may lead to life extension.

5.2 Nanotechnology in Environment:
Green nanotechnology is the development of clean technologies, "to minimize potential environmental and human health risks associated with the manufacture and use of nanotechnology products, and to encourage replacement of existing products with new Nano-products that are more environmentally friendly throughout their lifecycle.

5.2.1 Filtration:
A strong influence of photochemistry on waste-water treatment, air purification and energy storage devices is to be expected. Mechanical or chemical methods can be used for effective filtration techniques. One class of filtration techniques is based on the use of membranes with suitable whole sizes, whereby the liquid is pressed through the membrane. Nano porous membranes are suitable for a mechanical filtration with extremely small pores smaller than 10 nm and may be composed of nanotubes. Nano filtration is mainly used for the removal of ions or the separation of different fluids. On a larger scale, the membrane filtration technique is named ultrafiltration, which works down to between 10 and 100 nm. One important field of application for ultrafiltration is medical purposes as can be found in renal dialysis. Magnetic nano particles offer an effective and reliable method to remove heavy metal contaminants from waste water by making use of magnetic separation techniques.

5.3 Nanotechnology in Electronics:
Nanotechnology has already reached the electronics industry with features in microprocessors now less than 100 nanometers (nm) in size (Intel‘s Prescott processor uses 90 nm size features). Smaller sizes allow faster processing times and also more processing power to be packed into a given area. However, these advances are really only a continuation of existing microelectronics, and will reach their limit sometime around the end of the next decade (2018 or so) when it will be both physically impossible to ―write‖ or ―sketch‖ smaller features in silicon, and also because at extremely small sizes (less than 20 nm) silicon becomes electrically ―leaky‖ causing short circuits.

5.3.1 Computers: Computers and the industries around them are set to be advanced a further giant step with the application of nanotechnology. The limits of current technologies are quickly being reached, as memory and processor speeds hit their present theoretical maximums. Nanotechnology gives scope to develop new ideas and methods of running super-fast processors, storing data, and many other computational advances. It also allows for new applications which require more processing power, or to be smaller, or less energy intensive.

5.3.2 Telecommunications and Handheld Devices*:*
More and more in modern life, people are working on

the move, which means taking their laptop, phone, and other electronic equipment everywhere they go. There is a need to combine all these functions in one device so that people can communicate with colleagues and clients, whilst continuously having access to their files regardless of their location. Nanotechnology can offer improved versatility through faster data transfer, more mobile processing power and larger data storage.

5.4 Nanotechnology in Energy:

The most advanced nanotechnology projects related to energy are: storage, conversion, manufacturing improvements by reducing materials and process rates, energy saving (by better thermal insulation for example), and enhanced renewable energy sources.

5.4.1 Reduction of energy consumption:

A reduction of energy consumption can be reached by better insulation systems, by the use of more efficient lighting or combustion systems, and by use of lighter and stronger materials in the transportation sector. Currently used light bulbs only convert approximately 5% of the electrical energy into light. Nano technological approaches like **Light-Emitting Diodes** (LEDs) or **Quantum Caged Atoms** (QCAs) could lead to a strong reduction of energy consumption for illumination.

5.4.2 Increasing the efficiency of Energy production:

Today's best solar cells have layers of several different semiconductors stacked together to absorb light at different energies but they still only manage to use 40 percent of the Sun's energy. Commercially available solar cells have much lower efficiencies (15-20%). Nanotechnology could help increase the efficiency of light conversion by using nanostructures with a continuum of band gaps.

5.5 Nanotechnology in Heavy Industry:

There are many inevitable use of nanotechnology in heavy industries.

5.5.1 Aerospace:

Lighter and stronger materials will be of immense use to aircraft manufacturers, leading to increased performance. Spacecraft will also benefit, where weight is a major factor. Nanotechnology would help to reduce the size of equipment and thereby decrease fuel-consumption required to get it airborne.

5.5.2 Catalysis:

Chemical catalysis benefits especially from nanoparticles, due to the extremely large surface to volume ratio. The application potential of nanoparticles in catalysis ranges from fuel cell to catalytic converters and photo catalytic devices. Catalysis is also important for the production of chemicals.

The synthesis provides novel materials with tailored features and chemical properties: for example, nanoparticles with a distinct chemical surrounding, or specific optical properties. In this sense, chemistry is indeed a basic Nano science. In a short-term perspective, chemistry will provide novel ―nanomaterials‖ and in the long run, superior processes such as ―self-assembly‖ will enable energy and time preserving strategies. In a sense, all chemical synthesis can be understood in terms of nanotechnology, because of its ability to manufacture certain molecules. Thus, chemistry forms a base for nanotechnology providing tailor-made molecules, polymers, etc., as well as clusters and nanoparticles.

6. Conclusion:

As a conclusion to this topic we would like to say that Nanotechnology is a brand new technology that has just began, it is a revolutionary science that will change all what we knew before. The future that we were watching just in science fiction movies will in the near future be real.

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