A Study of Nanotechnology: The New Features

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Abstract

Nanotechnology is the science of the nanoscaleobjects around a nanometer in size. Nanotechnology is a multidisciplinary as well as an interdisciplinary area of inquiry and application. Nanotechnologies are increasing investments from the both governments and industries around the world, which offers great opportunities to explore the new emerging nanodevices, such as the carbannanotubes.It is possible to increase the capabilities of electronics devices and reduced their size, power consumptions and also weight, with the help of nanotechnology.It begins with a description of what nanotechnology is and how it relates to the scientific advances. It then describes the most likely future development of different technologies in a variety of fields. In this study we discuss the structure of nanotechnology in various fields, such as-physics, biology, chemistry, computer science and electrical engineering. This study gives a deep survey about the different aspects of the new nanotechnologies, such as materials, physics, and semiconductors, followed by an introduction of several nanodevices and then new nanotechnology features.In this study we also discuss several problems in the nanotechnology area and gives constructive ideas and predictions.

Keywords: Nanotechnology, Nanoscale, Nanodevices, Carban nanotubes, Semiconductors.

Introduction:

Nanotechnologies are considered to be the new generation of innovative technologies. Nanotechnology is a manipulation of matters on an atomic, molecular and macromolecular scale, to understand the properties that differ significantly from those on a larger scale. The word “nano” represents “nanometer” which is equal to one-billionth (10^{-9}) of a meter. Nanotechnologies are the design, characterisation, production and application of structures, devices and systems by controlling shape and size on a nanometer scale.The application of nanotechnology can occur in one, two or three dimensions of the materials. Nanomaterials are intrinsically different from their bulk counterparts and single atoms or molecules. Using structures designed at this nanoscale, there exist opportunities to build materials, devices, and systems with nano properties that can not only enhance existing technology but also offer novel features with potentially far-reaching technical, and societal implications. Nanotechnology products can be used for the design and processes in various areas. It has been demonstrated that nanotechnology has many unique characteristics, and can significantly fix the current problems which the non-nanotechnology faced, and may change the requirement and organization of design processes with its unique features. Nanotechnology have the great opportunities and continues to attract a lot of attention. Here we discuss the range of sciences currently covered by nanotechnology. It begins with a description of what nanotechnology is and how it relates to the scientific advances. It then describes the development of different technologies in a variety of fields. There are various concerted efforts since early 2000s by the government to promote the nanotechnology in India.

In this study we discuss the structure of nanotechnology in various fields such as-physics, biology, chemistry, computer science and electrical engineering. After this, we discussed the various new features of nanotechnology from different scientific areas, such as physics, materials, and information technologies. Some new features will display the different properties or characteristics for specific areas. We have investigated these new properties and the new abilities in the nano era. This combination of physicals, materials and semiconductors which commonly used in nanodevices, are a disruptive technology to changing the way of lives that are organized today. Here we will discuss the various problems related nanotechnology, and then follow with a potential prediction based on current developments.

How small is nano:A nanometer (nm) is equal to one-billionth (10^{-9}) of a meter. For comparison, the width of a human hair is approximately 80,000-100,000 nanometers. Human blood cells are 2,000 nm to 5,000 nm long, and a line of ten hydrogen atoms is 1 nm. There are 25,400,000 nanometers in 1 inch. Nanotechnology therefore holds out the promise of manipulating individual cell structure and function. Nanotechnology therefore holds the promise of manipulating individual cell structure and function. Nanotechnology can be viewed on a variety of levels. Thescience, engineering, and the technology related to the understanding and control of the matter at the length scale of 1 to 100 nm approximately. Dimensions between approximately 1-100 nm are known as the nanoscale. However, nanotechnology is not only working with the matter at the nanoscale, but also the research and development of the materials,devices, and systems that have novel properties and functions due to their nanoscale dimensions or components.

Structure of Nanotechnology:

Nanotechnology is distinguished by its interdisciplinary nature. The most advanced research and product development increase requires knowledge of disciplines that operated largely independently. These areas include:

Physics: The construction of the specific molecule is governed by the physical forces between the individual atoms to composing them. Nanotechnology involves the continued design of the novel molecules for specific purpose. However, the laws of physics will continue to govern the atoms which interact with each other.

Biology: Nanotechnology is the creation of small devices capablility of processing information on the nanoscale. The process in which the information is encoded in DNA, is used to build proteins, which then perform the complex tasks, including the building of more complex structures. It is also a part of all research in medical applications.

Chemistry: The interaction of different molecules is governed by chemical forces. Nanotechnology involves the controlledinteraction of different molecules in solution.

Computer Science: Nanotechnology also provides more efficient ways to transfer data onto a chip, at low power with minimum energy loss. For this data transmission technology, we have been focusing on electronic oscillations at the surface of metals. In addition,for the use of any nanodevice will be the need to exchange the information with them. Finally we required the ability to manage increasing the large amounts of information collected from a large network of sensors.

Electrical Engineering: Nanodevices will need a steady supply of power. Moving power into or out of the devices at that scale represents a unique challenge. In the field of information technology, the control of electric signals is also important to transistor switches and memory storage. A great deal of research is also developing nanotechnologies that can generate and manage power more efficiently.

New Features:

In this study, we will discuss the various new features of nanotechnology from different scientific areas, such as physics, materials, and information technologies. Some new features willdisplay the different properties or characteristics for specific areas.

(A)Physicals: Nanoparticles have their physical and chemical properties that are different from the same materials at larger scales. The properties of nanoparticles depend on their size, shape, surface characteristics and inner structure. They can change in the presence of certain chemicals. The composition of nanoparticles and chemical processes on their surface can be very complex. Nanoparticles can depends on the attractive or the repulsive interaction forces between them.

1: Magnetic: Magnetic nanoparticles are a part of nanoparticles which can be manipulated by using magnetic field gradients. Such particles basically consist of magnetic elements, such as iron, nickel and cobalt. Magnetic nanoparticle clusters which are made up of a number of individual magnetic nanoparticles are known as magnetic nanobeads with a diameter of 50200 nanometers. In most commonly cases, the particles range from 1-100 nm in size, shows the superparamagnetism. One of the most property of magnetic nanoparticles is the reduction from multidomains to a single domain as the particle size reduces to some limit values. Besides the large reduction of the coercive field for nanoparticles, the macroscopic quantum tunneling of the magnetic moment becomes its non-analyticity in the ground energy state of the infinite lattice system. A surface spin-glass layer is to be proven in the magnetic nanoparticles at low temperatures.At higher temperatures, a larger surface to volume ratio of the small nanoparticles shows a stronger surface anisotropic field to disorder the inner spins, causing quantum tunnelling.At high temperatures, single-domain magnetic nanoparticles are free to orient their spin directions and show the superparamagnetic properties.

2: Dielectric: A dielectric material is an electrical insulator which can be polarized by an applied electric field. When a dielectric material is placed in an electric field, electric charges do not flow through the material but they slightly shift from their average equilibrium positions causing dielectric polarization. The dielectric constants of metallic nanoparticles have been rarely reported in the microwave frequency range. The high microwave field absorption of the metallic particles involves in a microwave guide to determine the dielectric constant by measuring the attenuation and phase delay of the penetrating wave. The electrical and magnetic properties of many nanomaterials are completely different from those of their bulk counterparts. Changes in dielectric properties are described the quality to changes in the particle size, shape, and boundaries. The modified dielectric properties can be used as capacitors, optical filters and electronic memories. The conductivity of metallic nanoparticles behaves as non-conducting below a critical size and temperatures and also decreases as the particle size decreases, which suggests that the particles become less conducting as the particle size decreases.

(B)Materials: Most of the nanoscience and nanotechnology is concerned with producing new or materials. These materials can behave quite different at the nanoscale to the way as they do in bulk. This is because, the small size of the particles which increase surface area and reactivity, and also because the quantum effects which start to become significant.

1: Surface Ratio: In many fields of nanotechnology, advances in structured materials occurs both by evolutionary development of technologies and by revolutionary discoveries that generated new approaches to materials synthesis. As the particle size approaches to the 10-100 nm range, then the surface to volume ratio increases and properties become size dependent. More atoms are situated on the surface of the particle with the decrease in size. These particles can be considered as nanocrystals and the atoms within the particle are perfectly crystalline. The surface area shows a serious change of surface energy and surface morphology. The change in properties causes the improved catalytic ability, tunable wavelength-sensing ability and better-designed pigments. However, when the particle size is below 10 nm, the quantum effects dominate.

2: Quantum effects: Quantum mechanics is a branch of physics which deals with the physical phenomena at nanoscales, where the action is on the order of the Planck constant. Many phenomena become suitable as the size of the system decreases. These include statistical mechanical effects, as well as quantum mechanical effects. When the nanometer size range is reached, typically at distances of 100 nanometers or less, quantum effects can become significant, called quantum realm. Besides of this, a number of physical (mechanical, electrical, optical, etc.) properties change, when compared to macroscopic systems. One example is the increase in surface area to volume ratio, change the mechanical, thermal and catalytic properties of materials. Quantum confinement effects dominate the electrical and optical properties of systems at the nanoscale. It is also focused on quantum dots, that are semiconductor nanoparticles which can be ’tuned’ to emit or absorb particular colors of light for use in solar energy or fluorescent biological labels.

3: 3D Structure: Materials can be divided by the overall dimensionalities of the structure and the class of compound. Some recent novel developments include producing zero-dimensional (0D)(dots), one-dimensional (1D)(wires and tubes), two-dimensional (2D)(monolayer films) and three-dimensional (3D)(particles) for the functional applications. This study will be concentrated on the developments and structures of 3D carbon particles. Fullerene has the 3D structure of carbon particles. It consists of 20 hexagonal and 12 pentagonal rings as the basis of an icosahedral symmetry closed cage structure. Each carbon atom is bonded to three others. The Buckminsterfullerene C_{60} molecule has two bond lengths, first the 6:6 ring bonds which can be considered as “double bonds” and second are shorter than the 6:5 bonds. It tends to avoid double bonds in the pentagonal rings, resulting in poor electron delocalization. C_{60}behaves as an electron deficient alkene, and reacts easily with electron rich species. In this study, an infinite number of fullerenes can exist, their structure based on pentagonal and hexagonal rings, for making icosahedra.

(C)Semiconductor: A semiconductor material has an electrical conductivity betweena conductor, such as copper, and an insulator, such as glass. Their resistivity is higher than that of a conductor but lower than that of an insulator. At very low temperatures of the order of 0^0K(-273^0C), semiconductors act like insulators. Semiconducting materials exist in elemental and compound materials. Some of nanostructure materials are as-

TABLE- NANOSTRUCTURED MATERIALS

Nano tubes	Carbon, SnO_2, InAs, GaAs, BN, ZrO_2, MoS_2, peptides, metallo porphyrin, SiO_2, Cu
Nano wires	Si, In, InAs, MgO, ZnO, SnO_2, TiO_2, Au, Ag, Ni, Cu, Bi, Co, Pb, CdS, PbSe, FeCo, FeNi, BN, ZnS, ZnSe, CdSe, SiGe, polyanaline
Nano dots	GaAs, InP, Si, InAs, CdS, CdSe, TiO_2, ZnS, Fe_2O_3, MnO_4

1: Nanotubes: Nanotubes are of cylindrical walls that are only as wide as a single carbon atom. These tubes of carbon are usually only a few nanometres wide, but they can range from less than a micrometer to several millimetres in length. Their unique molecular structure shows the results in extraordinary macroscopic properties, including high tensile strength, high electrical conductivity, high heat conductivity and relative chemical inactivity. Carbon nanotubes are chemically bonded with sp^2 bonds, an extremely strong form of molecular interaction. Properties of carbon nanotubes depends on single-wall carbon nanotubes (SWNT) or Multiwall Nanotubes (MWNT).

2: Nanowires: Nanotubes of the length longer than 1 µm are basically called nanowires or (nanofibers). Nanowires are attractive for nanoscience studies and also for nanotechnology applications. They can be prepared by physics, chemistry, metallic wires, and semiconductors. Because of their unique density of electronic states, nanowires described different electrical, optical, and magnetic properties from their bulk 3D crystalline counterparts.The properties may depend on their surface condition and geometrical configuration, due to the enhanced surface-to-volume ratio in nanowires.

3: Quantum dots: Quantum dots aremade from a semiconductor such as silicon. They are crystals a few nanometers wide, so they are typically a few dozen atoms across and contain anything from perhaps a hundred to a thousand atoms. Quantum dots also have quantised energy levels. In this study of quantum dots (QD) it has a longer history, which arising as it does out of the semiconductor field of quantum wells, low dimensional electron gasses, heterostructures etc. The biggest quantum dots produce the longest wavelengths and lowest frequencies, while the smallest quantum dots produce the shorter wavelengths and higher frequencies. The first semiconductor quantum dots are fluorescent. Quantum dots are now realizable in various shapes and sizes and device applications.

DISCUSSIONS:

Nanotechnologies have new abilities to the state of-the-art technologies and are projected to be commercially available in the near future. In this study we have investigated these new properties and the new abilities in the nano era. This combination of physicals materials and semiconductors which commonly used in nanodevices, are a disruptive technology to changing the way of lives that are organized today. In this study, we will discuss various problems related nanotechnology, and follow with a potential prediction based on current developments.

(a)Problems with Nanotechnology: When a new technology grown, it usually sparks conflicts between those wishing to exploit it as soon as possible and those wishing to wait forever, if necessary to have it proved absolutely safe. Nanotechnology is relatively a new technology comparedwithother technologies. It is not a surprise that the public is wary of its potential for harm, as well as excited by its potential for good.

1: Health and Environment:A wide range of nanotechnologies depend on nanoscale components which are confined in closed systems and therefore cannot come into direct contact with organisms, neither the human body nor bacteria in the environment.It is found that most nanotechnologies pose no new risks to humans or the environment. It is unclear that nanoparticles would do if they entered the human body. Micrometersized clumps of nanoparticles are relatively unreactive because their surface areas are smaller than that of the same number of individual nanoparticles, and they are also too large to enter the blood stream when breathed in. But individual nanoparticles can pass from the lungs into the bloodstream, and are more reactive.

Another issue is the unknown toxicity of materials to health. Materials can behave quite differently at the nanoscale to the way as they do in bulk. However, it means that their toxicity may be different from that of the same chemical in the form of larger particles. There are examples where nanoparticles can produce toxic effects even if the bulk substance is non-poisonous. This arises partly because of their increased surface area and also because, should the nanoparticles enter the body through inhalation, ingestion, or absorption through the skin, they are able to move around and enter cells more easily than larger particles.Although we breathe in millions of pollutant particles with each breath without serious harm, increases only 10µg/$m^3$are continuously associated with a 1% increase in cardiac deaths. Toxicological studies have been investigated nanoparticles of low solubility and surface activity.

2: Impacts on Society and the Economy: The main point is that socioeconomical impacts could give rise to a 'nanodivide' between nations with advanced nanotech capabilities and others without increasing the global development gap. Although more than 50 nations, among of them newly industrialising countries, have set up a national nanotechnology policy like the NNI, a great deal of nanotech research takes place in the United States, the EU, Japan, and recently also China, India, and Russia. These regions account for the majority of scientific publications as well as funding and patents. So the risk of a nanodivide is not merely hypothetical, although it is unclear how it will eventually manifest. Within industrialised countries, nanotechnologies could support problematic trends. Nanotechnologies for sensoring and computing could also befacilitatethe more elaborate surveillance systems because of their potential to miniaturise relevant technologies in order to intrude into the privacy of citizens. Moreover, it has cautioned that nanotechnologies for military use could destabilise international security and perhaps even trigger another arms race in the coming decades.

3: Uncontrollability: Nanotechnology will continue to change our vision, expectations, and abilities to control the materials world. These developments in nanoscale will definitely affect the physical and chemical properties of materials. Recent main achievements include the ability to observe structure at its atomic level and measure the strength and hardness of microscopic and nanoscopic phases of composite materials. However, one point is that nanotechnology could go out of control if it is not correctly used. This point is based on the idea of small machines that can replicate themselves automatically ("assemblers) and that escapefrom the laboratory and eat the earth. Any statement about the future is always personal opinion. But there is no way that such devices can exist on earth. The idea of small, self-replicating machines does not seem impossible now. After all, bacteria exist but developing such machines de novo a task close to developing a new form of life that seems to the public to be intractably difficult; it continues to seem so. The storage devices can be created appeared soon after STM (STMicroelectronics) capable of manipulating separate atoms has been developed. Some progress for this type storage has been achieved. However, the uncontrollability of the STM probe tip at the atomic level and the limited set of substrates allowing the work under normal conditions that have yielded no way of going beyond separate successful experiments.

4: Privacy and Ethical: The most serious risk of nanotechnology comes, not only from the hypothetical revolutionary materials or systems, but also from the uses of evolutionary nanotechnologies that are already developing rapidly. The continuing extension of electronics and telecommunications are fast processors, methods for searching databases, ubiquitous sensors, electronic commerce and banking, commercial and governmental record keeping into most aspects of life is increasingly making it possible to collect, store, and sort enormous quantities of data about people. These data can be used to identify and characterized individuals, and the ease with which they can be collected and manipulated poses a directthreattohistoricalnorms of individualprivacy. The societal concerns arises in the development of nanotechnologies are centeredaround 'who controls the uses of nanotechnologies' and 'who benefits from uses of nanotechnologies'. The convergence of nanotechnology with other technologies is expected to lead to far-reaching developments, which may raise social and ethical issues. A number of the social and ethical issues that might be generated by nanotechnologies should be investigated. The ethical and social implications of advanced technologies should be the part of the formal training of all research students and staff working in these areas.

(b) Prediction: This study predicts the current development trends from the information and technology aspects considering the new nanotechnologies.

1) Sustainable Nanomaterials: Nanotechnology is the most famous emerging technologies and it heralded as a key technology for the 21st century. Potential innovations offer numerous benefits. There are great expectations among scientists, policymaker and industry representatives that nanotechnology will contribute to economic prosperity and sustainable development. On the other way, nanotechnology has been the subject of an extensive public debate in Europe and the United States. We can say that, nanotechnology is a case for technology assessment.Nanotechnology has the widespread applications in the field of 'nanomaterials'. Nanomaterials are an essential part of the whole field of nanotechnology. They may be considered as the most important bridge between basic research and marketable products and processes. Nanomaterials show the great economic potential, e.g. by substituting other materials or by making available new functionalities and thus enabling new products and creating new markets. Nanomaterials may also contribute to the reduction of the ecological footprint of the classical production processes by reducing energy and material consumption.

According to the National Nanotechnology Initiative (NNI), nanoscale materials are used in electronics, chemicals, energy, and biomedical, among other industries. These products include paints, sporting goods, cosmetics, electronics, and surface coatings, among other applications. Sustainable technologies are characterized by high benefits, low risks for the short and long term and social acceptance.Entergreen nanotechnology, to managing the environmental, health, and safety (EHS) risks potentially posed by nanoscale materials to ensure their responsible and sustainable development. There are two descriptions of green nanotechnology. The first involves nanoproducts that provide the solutions to the environmental challenges. And the second involves producing nanomaterials and nano enabled products to minimize human and environmental harm.Green nanotechnologies that focused on the full lifecycle can better prepare users for recycling, reuse, or remanufacture of nanomaterials andnano-enabled products, thus minimizing generating new hazards through unintended consequences.

2) Nano-Circuits: Nanocircuits are the electrical circuits that operating on the nanometer scale, which are used into the quantum realm, and quantum mechanical effects become very important. The various proposals have been made to implement nano-circuits, including nanowires, single-election transistors, quantum dot cellular automate, and nanoscale crossbar latches. For example taking the three-dimensional integrated circuit (3D IC) which manufactured by stacking silicon wafers or dies and interconnecting them vertically, e.g., using through-silicon vias (TSVx), so that they behave like a single device to achieve performance improvements at reduced power and smaller footprint than conventional two dimensional processes. Stacking is important in 3DIC. There exist many key stacking approaches being implemented and explored, including die-to-die, die-to-wafer and wafer-to-wafer. However, these technologies carry new challenges, such as cost, yield, design complexity, TSV-introduced overhead, lack of standards, etc. Thus, these challenges urgently require new technology to deal with them. Nanotechnology provides a good solution for these challenges.

CONCLUSION:

Nanotechnology can be viewed as a new phase of technology in general with a huge potential for change, encompassing amultitude of concrete nanotechnologies.Nanotechnology has the various new features for different scientific areas, such as physics, materials, and information technologies.Nanotechnologies have new abilities to the state of-the-art technologies and are projected to be commercially available in the near future.Nanotechnologies offer the great opportunities and continue to attractalotofattentionbecauseoftheir potential impactsonan incredibly wide range of industries and markets. Nanotechnology is relatively a new technology compared with other technologies. It is not a surprise that the public is wary of its potential for harm, as well as excited by its potential for good.Consequently, this technology is evolving quickly and will develop faster over the coming years. It is also essential to description the uncertainties and the potential problems which nanotechnologies may take in an economic and safe manner.

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