NANOTECHNOLOGY: PROSPECTS AND CHALLENGES

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ABSTRACT

Nanotechnology emerges from the classic talk entitled "There's plenty of Room at the Bottom" and has got shape as a new field of research after the invention of scanning tunneling microscope (STM) and atomic force microscope (AFM). Finally, the discovery of fullerenes and inventing Carbon Nanotube Tube (CNT) in 1990 became the launching pad of Nanotechnology. Fundamental concerns, synthesizing and characterization technique have been discussed for understanding Nanotechnology in this review article. After 30 years of the birth of this technology, manufactured Nano-products have reached to around 3500 and become available for public usage. Worldwide scientists are pursuing for synthesizing nanomaterials with various objectives in almost all encompassed fields of science, engineering and technologies. As such, the scope of applications of Nanotechnology is becoming wider, and leading it to be more prospective. But in the meantime, some issues on the usage of Nano-products have been surfaced those are to be mitigated and thereby scientist, engineers and technologists would have to face as challenges in the near future. All these prospects and issues are discussed briefly in this review article for the purpose.

Key Words: Nanotechnology; Nanoscience; Nanoparticles; Nanotube; Fullerene; Quantum Dot.

1.0 INTRODUCTION

Nowadays, nanotechnology is promising and prospective research field, which leads to tap the potentiality of nanomaterials for using in applications to the benefit of the mankind. Nanotechnology is science, engineering and technology conducted at the nanoscale (in the order of one billionth of a meter i.e. 10-9 m). The researches on various aspects of nanotechnology are being continued worldwide depending on respective perspective. Already people started to enjoy the discoveries and deliverables as blessings of nanotechnology from their day to day life to the live savings medication. Remarkable applications have found in electronic and computer industries from the mid of 1980s. By the time, the scopes of nanotechnology have been widened across almost all the fields of sciences, engineering and technology. The significant development has found to result from the ability of manipulating and controlling atoms and molecules in nanoscale range after the invention of scanning tunneling microscope (STM) and atomic force microscope (AFM). Because the particle size has spatial influence on mechanical, electrical, optical, catalytic, magnetic properties of the materials in solid state in particular.

As of 10 March, 2011, the "Project on Emerging Nanotechnologies" estimates that over 1300 manufactured nanotech products have publicly available with new ones hitting the market at a pace of 3–4 per week. Meanwhile list of applications of nanotechnology tends to be almost boundless. Besides, various branches of nanotechnology like nanophysics, nanoelectronics, nano-optics, nano-magnetism, nanoparticles and so on have emerged out with different scopes and perspectives to study. Despite countless prospects, sort of agendas have already come in focus relating to health hazards and adverse effect on the environment. So, these are the challenges what researchers, scientists, technologists need to face in the near future.

Hence, the objective of this paper is to have a comprehensive study on prospects and related adversaries to face the challenges in the days to come.

2.0 HISTORICAL BACKGROUND

The ideas and concepts behind the nanotechnology originated from the classic talk, entitled "There's Plenty of Room at the Bottom" by physicist Richard Feynman at the annual meeting of American Physical Society on 29th December 1959 in California Institute of Technology (Caltech) long before the term was used. In his talk, Richard Feynman described how the scientists would be able to manipulate and control the atoms and molecules in the solids. Over a decade later, Japanese scientist, Professor Norio Taniguchi coined the term "nanotechnology" during his exploration of ultra-precision machining.

Nanotechnology has emerged as a prospective field of study from three remarkable phenomenon; such as (i) quantum hall effect across two dimensional (2D) electron gas, (ii) the invention of scanning tunneling microscope (STM) and (iii) the discovery of fullerene (C_{60}) as a new form of carbon, which was discovered in 1985 by Harry Kroto, Richard Smalley and Robert Curl jointly [1]. Another remarkable invention was the atomic force microscopy (AFM) having capability to see, measure and assemble the atoms individually, gave impetus to the birth of nanotechnology. Finally in 1990, the invention of carbon nanotube (CNT) has established the launching pad of today's nanotechnology. A comparison of nanomaterial sizes is depicted in figure-1(a) for better understanding.

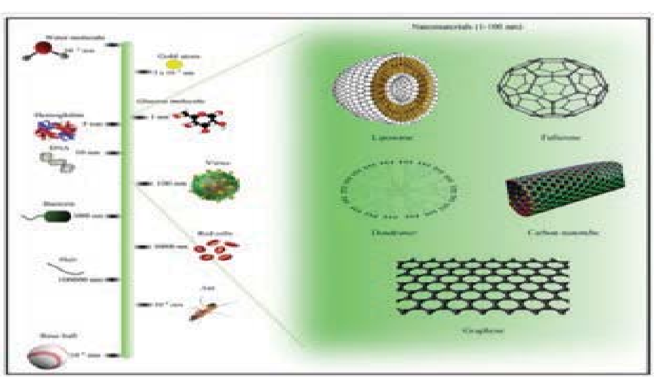


Fig 1: (a) Comparison of nanomaterials sizes

Fig 1: (b) Medieval stained glass windows (Source: free Wikipedia)

Although modern nanotechnology are quite new in the era of material science, Nanoscale materials were used for centuries as evident from the stained glass window of the medieval church where the artists used alternate-sized gold and silver to create beautiful colors without knowing the process and responsible factors for such colors as shown in figure-1(b). As such, today's scientists and engineers are involved to investigate a variety of ways to deliberately make materials to tap enhanced properties like higher strength, lighter weight, increased control of light spectrum and greater chemical reactivity compared to their larger scale counterparts both in top-down and bottom-up approaches.

3.0 FUNDAMENTAL CONCERNS

3.1. Synthesize or fabrication

The fundamental concept of nanotechnology is the projected ability of fabricating or synthesizing materials in nanoscale either from bottom up or top down approach using technique and tools being developed today. The materials of which at least one dimension out of three dimensions produced in nanoscale i.e. in the order of one-billionth of a meter are usually referred to as nanomaterials. The bottom up approach represents the molecular perspective and top-down approach the material perspective. In bottom-up approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition . On the other hand, in the top-down approach, nanomaterials are constructed from the larger entities without atomic level control. However, approaches determines the synthesize method or technique for nanomaterial/nanoparticles production. The physicists usually follow both the top-down and bottom-up approaches depending on research objective and perspective as well.

3.2. Effects of Size

3.2.1 Quantum effect

Several phenomena become pronounced when the size of materials decreases. The phenomenon includes statistical, mechanical and quantum-mechanical effects. The change in electronic properties of solids results from the quantum effect when the size of the material reduces to nanoscale and become significant in the range below 100 nm. So, materials reduced to the nanoscale can show different properties compared to what they exhibit on a macro scale and thus nanoscale size of the particles enabling them in unique applications. Some remarkable examples are as follows:

o Opaque substances can become transparent such as Copper (Cu)
o Stable materials can turn into combustible like Aluminum (Al)
o Insoluble materials may become soluble for example Gold (Au)
o Chemical inert materials like gold can serve as a potent chemical catalyst at the nanoscale.

3.2.2. Surface-to-volume ratio effect

When a material size reduces and approaches to nanoscale then the surface area becomes more and more compared to its volume and sometimes causes unpredictable morphological changes. That is why, perhaps W. Pauli said, "God made solids but the surface is the work of devil". When the dimensionality of a material becomes in the range of nanoscale, the surface atoms with their unpaired spins and uncompensated bonds strongly modify the density of states, enhance columbic force, resulting discrete energy levels and also quantum coherent effect in transport. Thus the enhanced of surface-to-volume ratio at nanoscale causes the changes in mechanical, thermal and catalytic properties of the materials uniquely.

3.3 Nanomaterials

3.3.1 Dimensionality

Any condensed matter having at least one out of its three dimensions is sized in nanoscale and referred to as nanosystem or nanomaterials, which can also be called the building block of nanoscience as well as nanotechnology. According to this dimensionality, nanomaterials are classified as:

o 0-D: Diameter in between 1-100 nm. They are nanoparticles.
o 1-D: Diameter in between 1-100 nm but length 100 nm and above. They are nanowires and nanotube.
o 2-D: Thickness is 1 atom. They are nanosheets.
o 3-D: Box-shaped graphene (BSG) nanostructure is an example of 3D nanomaterials. BSG nanostructure has appeared after mechanical cleavage of pyrolitic graphite. This nanostructure is a multilayer system of parallel hollow nanochannels located along the surface and having quadrangular cross-section. The thickness of the channel walls is approximately equal to 1 nm. The typical width of channel faces makes about 25 nm.

3.3.2. Categories

The nanomaterials are found to have in four categories, such as: (i) nanoparticles, (ii) carbon nanotube, (iii) fullerenes and (iv) metamaterial.

3.3.2.1. Nanoparticles

Particles having 1-100 nm sized dimension are referred to as nanoparticles. In nanotechnology, a particle is defined as a small object that behaves as a whole unit with respect to its transport and properties. Particles are further classified according to diameter. Ultrafine particles are the same as nanoparticles and between 1 and

100 nanometers in size, fine particles are sized between 100 and 2,500 nanometers, and coarse particles cover a range between 2,500 and 10,000 nm. Nanoparticles are, in effect, a bridge between bulk materials and atomic or molecular structures. As such research of nanoparticles is currently an area of intense scientific interest due to a wide variety of potential applications in biomedical, optical and electronic fields.

3.3.2.2. Carbon Nanotube

Carbon nanotubes (CNTs) are the allotropes of carbon with a cylindrical nanostructure and constructed with length to diameter ratio of up to 132, 000000: 1, as shown in figure-2, which is significantly larger than any other materials. Carbon nanotubes are usually used as additives to various structural materials because of their extraordinary thermal conductivity, mechanical and electrical properties. For example, they form a tiny portion of baseball bats, golf clubs and car parts or Damascus steels[ii]. Carbon nanotubes are made of long and one-atom thick sheets of carbon, called graphene, by rolling the sheet at a specific radius, and specific and discrete (chiral) angles. The combination of angle and radius determines the nanotube properties like whether the individual nanotube shell is a metal or semiconductor. These nanotubes are categorized as single walled nanotube (SWNT) or multi-walled nanotube (MWNT).

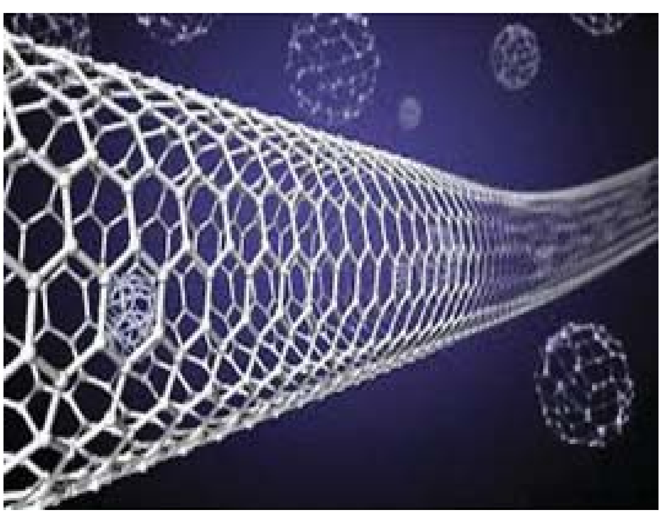


Fig 2: Carbon Nanotube (Source: free Wikipedia)

3.3.2.3. Fullerenes

A fullerene is a molecule of carbon in the form of hollow sphere, ellipsoid or tube, and any other shapes. Spherical fullerene is also known as Buckyball as shown in figure-3. Fullerenes are similar in structure to graphite, which is composed of stacked graphene sheets of linked hexagonal rings; but they may also contain pentagonal (or sometimes heptagonal) rings. Its discovery has extended the number of carbon allotropes. They have been the subject of intense research on their unique chemistry for their technological applications, particularly in material science, electronics and nanotechnology.

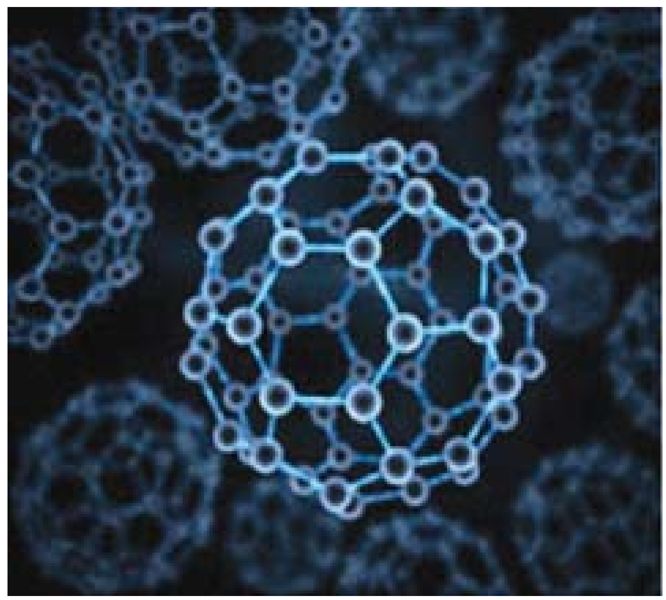


Fig 3: Fullerene (Source: free Wikipedia)

3.3.2.4. Metamaterials

They are artificial materials engineered to infuse properties which may not readily available in nature. These materials employ the inclusion of small inhomogeneity to enact effective macroscopic behavior. Investigating of materials with negative refractive index is the primary focus in research. Electromagnetic, photonic, acoustic and seismic metamaterials are current areas of active research.

3.3.3. Quantum Dots (QDs)

The QDs are the nanoscale semiconductor devices as depicted in figure-4, which can be made by colloidal synthesis, plasma synthesis and mechanical fabrication. In this device, either electron or electron holes are confined in three spatial directions. Their electronic properties fall between bulk semiconductor and those of discrete molecules of comparable sizes. Their band gap, which is responsible for optoelectronic properties, can be tuned as a function of particle size and shape for a given composition. For example, the photoluminescence of a QD can be manipulated to specific wavelengths by controlling particle diameter. Larger QDs (radius of 5-6 nm, for example) emit longer wavelengths resulting in emission colors such as orange or red. Smaller QDs (radius of 2-3 nm, for example) emit shorter wavelengths resulting in colors like blue and green, although the specific colors and sizes vary depending on the exact composition of the QD. Because of the high tunability of properties, QDs are of interest in research for many applications like transistors, solar-cells, LEDs, diode lasers and second-harmonic generation. Besides, the ability of QDs to precisely convert and tune a spectrum makes them ideal for LCD displays. Previous LCD displays can waste energy converting red-green poor, blue-yellow rich white light into a more balanced lighting. The first commercial application of quantum dots was the Sony XBR X900A series of flat panel televisions released in 2013.QDs are also being researched as possible quantum bits (QBITS) for quantum computing. Beyond electronic applications, QDs are also being investigated in the medical field for imaging. Additionally, their small size allows for QDs to be suspended in solution which leads to possible uses in inkjet-printing and coating. These processing techniques result in less-expensive and less time consuming methods of semiconductor fabrication.

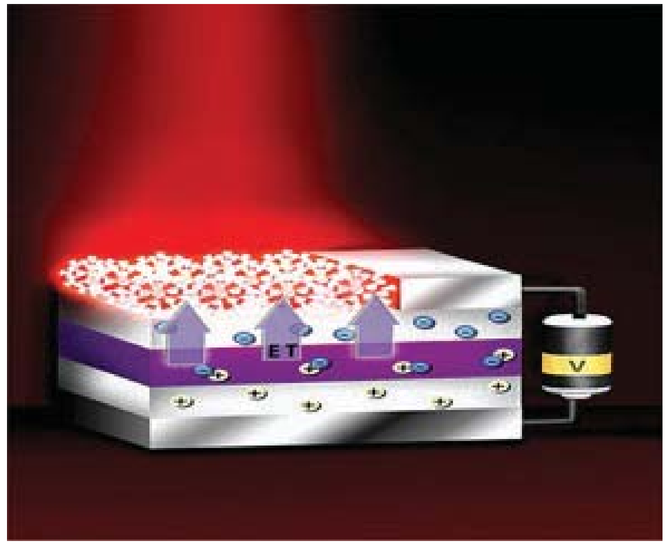


Fig 4: This device transfers energy from nano-thin layers of quantum wells to nanocrystals above them, causing the nanocrystals to emit visible light (Source: free Wikipedia)

4. TECHNIQUE OF SYNTHESIZE AND CHARACTERIZATION

4.1. Synthesize Technique

There are mainly two approaches to synthesize nanoparticles or nanodevices, such as (i) Top-down approaches and (ii) Bottom-up approaches.

4.1.1 Top-down approach

Lithography is one of the top-down fabrication techniques where a bulk material is reduced in size to nanoscale pattern. Optical lithography, X-ray lithography, dip-pen nanolithography, electron beam lithography also developed for nanoparticles synthesizes or nanodevices fabrication in the top-down approach. Out of them, electron beam lithography (EBL) is being popularly used since 1960. Despite, solid state silicon methods used in microprocessor fabrication and solid state techniques found to be used to create devices such as nanoelectromechanical system (NEMS) and microelectromechanical systems (MEMS).

Besides, Focused ion beam (FIB) can be used to remove or deposit materials when precursor gases are applied at the same time. Notable here, that recently, atomic force microscope (AFM) tips are also being used as a nanoscale "write head" to deposit a resist, which is then followed by an etching process to remove material in a top-down method.

4.1.2. Bottom-up approach

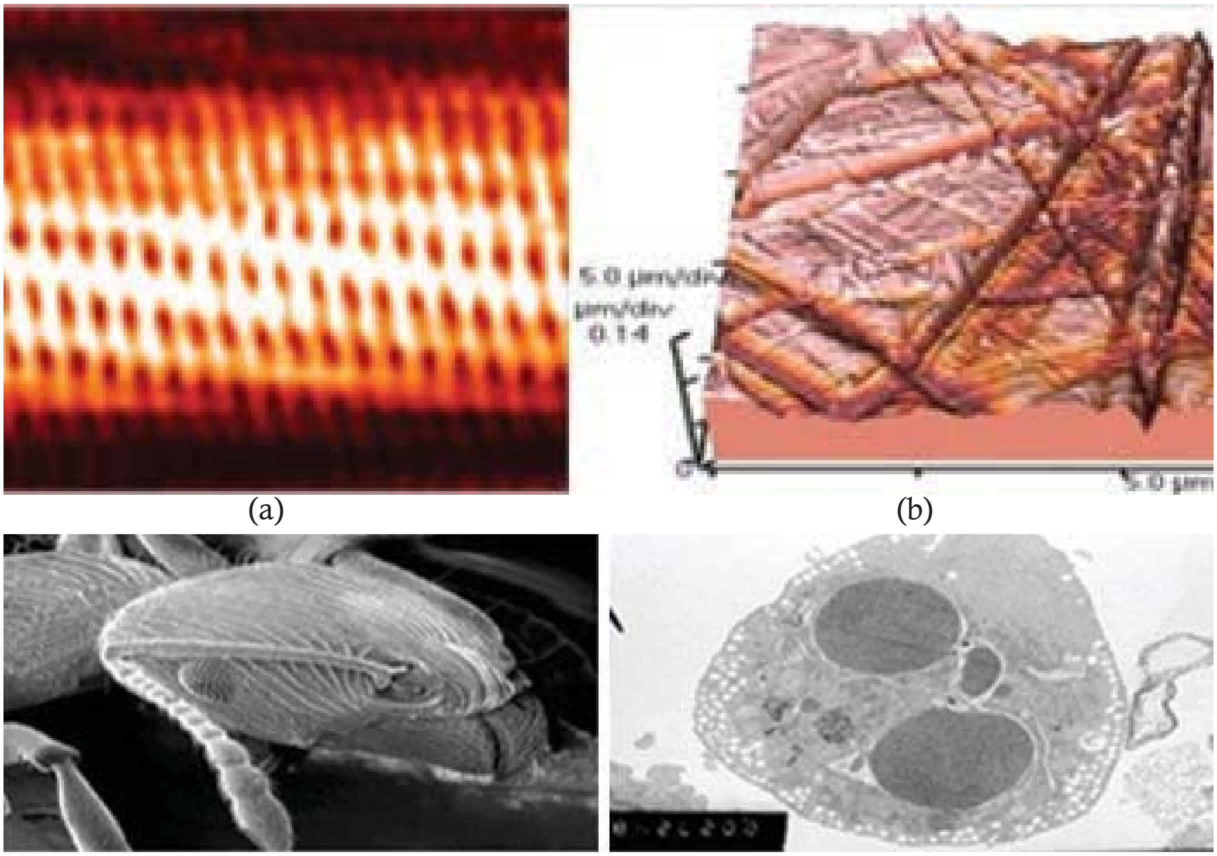
Bottom-up techniques built or grow larger structures atom by atom and molecule by molecule. In this approach, chemical synthesis, self-assembly and positional assembly techniques are usually used for fabrication of nanoparticles and devices. Another popular technique in bottom-up approaches is molecular beam epitaxy (MBE), which is being used for the purpose since 1960. Complex structures are built up by automatic lay down of precise layers of atoms in the process of MBE. This technique is being used widely to make samples and devices for the newly emerging field of spintronics . Despite, in the bottom-up approaches, solid state techniques are also used to synthesize samples, where in Sol-gel, combustion, citrate gel and solid state reaction method with magnetic or ball milling are popularly used in fabrication of the composites of nanoparticles. Besides, AFM tips can be used as a nanoscale "write head" to deposit a chemical upon a surface in a desired pattern in a process called dip pen nanolithography. This technique fits into the larger subfield of nanolithography. Other than the techniques as stated above, by using, feature-oriented scanning approach, atoms or molecules can be moved around on a surface with scanning probe microscopy techniques with different tips. At present, it is expensive and time-consuming for mass production but very suitable for laboratory experimentation

4.2. Characterization

Characterization refers to finding various properties like structural, mechanical, electrical, magnetic etc. of samples under investigation using tools and techniques. Structural properties are prime needs to find after synthesize the sample. There are several developments in tools and techniques to determine the structural properties. STM and AFM are the early versions of scanning probes that has launched the pad of nanotechnology. Other types of powerful scanning probes are also developed by the time for the purpose. A brief description on widely used scanning probes is given below:

a. **STM** is an instrument for imaging surfaces at the atomic level. It is developed based on the concept of quantum tunneling .When a conducting tip is brought very near to the surface to be examined, a bias (voltage difference) applied between the two can allow electrons to tunnel through the vacuum between them. The resulting tunneling current is a function of tip position, applied voltage, and the local density of states (LDOS) of the sample. Information is acquired by monitoring the current as the tip's position scans across the surface, and is usually displayed in image form. STM can be a challenging technique, as it requires extremely clean and stable surfaces, sharp tips, excellent vibration control, and sophisticated electronics, but nonetheless many hobbyists have built their own. An STM image of single-walled nanotube is depicted in figure-5(a). There are many other STM based scanning probes developed so far such as photon scanning microscopy (PSTM), spin polarized scanning tunneling microscopy (SPSTM) [2].

b. **AFM** is a type of scanning probe microscopy (SPM) with high resolution in the order of a fraction of a nanometer [3]. The information is gathered by "feeling" or "touching" the surface with a mechanical probe. Piezoelectric elements that facilitate tiny but accurate and precise movements on (electronic) command enable very precise scanning. It has three abilities namely force measurement, imaging and manipulation. It can give the information about the surface topology of the sample. The surface topography is commonly displayed as a pseudo color plot . An AFM image is a simulated image based on the height of each point of the surface and, in fact, each point (x, y) of the surface has a height h(x, y). A typical image is depicted in figure-5(b). In manipulation, the forces between tip and sample can also be used to change the properties of the sample in a controlled way. Examples of this include atomic manipulation scanning probe lithography and local stimulation of cells. Simultaneous with the acquisition of topographical images, other properties of the sample can be measured locally and displayed as an image, often with similarly high resolution.



(a) (b)

(c) (d)

Fig 5: (a) STM image (b) AFM Image (c) SEM Image (d) TEM Image (Source: free Wikipedia)

c. **SEM** is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with the atoms in the sample, producing various signals that contain information about the sample's topology and composition. A typical image is depicted in figure-5(c).

d. **TEM** is a microscopy technique in which a beam of electrons is transmitted through an ultra-thin specimen, interacting with the specimen as it passes through it. An image is formed from the interaction of the electrons transmitted through the specimen; the image is magnified and focused onto an imaging device, such as a fluorescent screen, on a layer of photographic film, or to be detected by a sensor such as a CCD camera. TEMs are capable of imaging at a significantly higher resolution than light microscopes, owing to the small de Broglie wavelength of electrons. TEMs find application in cancer research, **virology**, materials science as well as pollution, nanotechnology and semiconductor research. Alternate modes of use allow for the TEM to observe modulations in chemical identity, crystal orientation, electronic structure and sample induced electron phase shift as well as the regular absorption based imaging. A typical image is depicted in figure-5(d).

5. APPLICATIONS AND PROSPECTS

5.1. Applications

The applications of nanotechnology in the commercial products have started since 2000. Most applications are limited to the bulk use of passive nanomaterials. Examples include titanium dioxide and zinc oxide nanoparticles. They are used in sunscreen, cosmetics and some food products. Besides, Silver nanoparticles are being used in food packaging, clothing, disinfectants and household appliances. Carbon nanotube for strain-resistant textiles and cerium as fuel catalyst are the other bulk applications of the nanotechnology. As of March 10, 2011, the

"Project of Emerging Nanotechnologies" has estimated that over 1300 manufacturer-identified nanotech products are publicly available, with new ones hitting the market at a pace of 3–4 per week [4]. Accordingly, around more 1200 nanotech products seem to be publicly available by 2016. Accounts of recent applications are appended below:

a. **Drug delivery** is one of the medicinal applications, in that nanoparticles are employed to deliver drugs, heat, light or any other substances to specific type of cells such as cancer cells [5]. **Nanosponges** have been developed for therapy, which absorbs toxins and remove them from the blood stream. Researchers at MIT have developed a sensor using carbon nanotubes embedded in a gel that can be injected under the skin to monitor the level of nitric oxide in the bloodstream. The level of nitric oxide is important because it indicates inflammation, allowing easy monitoring of inflammatory diseases. Researchers at the University of Houston are developing a technique to kill bacteria using gold nanoparticles and infrared light. This method may lead to improved cleaning of instruments in hospital settings. Researchers at the University of Colorado Boulder are investigating the use of quantum dots to treat antibiotic resistant infections. Researchers at the University of New South Wales are investigating the use of polymer coated iron oxide nanoparticles to treat chronic bacterial infections.

b. **Clay nanocomposites** are being used to provide an impermeable barrier to gasses such as oxygen or carbon dioxide in lightweight bottles, cartons and packaging films. **Storage bins** are being produced with silver nanoparticles embedded in the plastic. The silver nanoparticles kill bacteria from any material that was previously stored in the bins and thus minimizing health risks from harmful bacteria.

c. Researchers at the Technische Universität München have demonstrated a method of spraying carbon nanotubes onto flexible plastic surfaces to produce sensors. The researchers believe that this method could produce low cost sensors on surfaces such as the plastic film wrapping food, so that the sensor could detect spoiled food. Researchers are using silicate nanoparticles to provide a barrier to gasses (for example oxygen), or moisture in a plastic film used for packaging. This could reduce the possibly of food spoiling or drying out. Zinc oxide nanoparticles can be incorporated into plastic packaging to block UV rays and provide anti-bacterial protection, while improving the strength and stability of the plastic film. **Nanosensors** are being developed that can detect bacteria and other contaminates, such as salmonella, at a packaging plant. This will allow for frequent testing at a much lower cost than sending samples to a lab for analysis. This point-of-packaging testing, if conducted properly, has the potential to dramatically reduce the chance of contaminated food reaching grocery store shelves.

d. Construction materials, military goods, nanomachining of nanorods, nanowires, and few layers of grapheme, paint etc. are the potential applications of nanotechnology in industry. In electronic industry, high capability storage devices, various sensors, actuators, displays of computer monitor, TV, cellular phones and light and water proof covers of them, etc. are some remarkable applications where nanotechnologies are being used to enhance capability, reduce size for miniaturization and many other extraordinary features. Besides, nanotechnologies are being used for purification and environmental clean-up applications include desalination of water, water filtration, waste water treatment, ground water treatment and other nanoremediation.

e. Nanomedicine is the medical applications of nanotechnology that ranges from the nanomaterials as medication and biological devices to nanoelectronics and biosensors. 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.

However, as nanotechnology encompasses almost all the fields of science, engineering and technology, so its list of applications is very large and also increasing day by day [6].

5.2. Prospects

The term "Prospect" here refers to forecast of probable applications of nanotechnology in the future, which certainly depends on the research in various branches of nanotechnology and their integration. In the existing context, it is noticed that its potential applications are a combination of both semiconductor and biotechnology. As such, worldwide researches are being continued in different branches depending on their respective perspective. Hence, an idea on probabilistic development in application of nanotechnology, nanomaterials/nanoparticles, in particular, is focused below:

a. **Nanotechnology** is an integrated technology centering the nanomaterials. These nanomaterials are independently synthesized using the basic sciences such as chemistry, physics and, for some nanoparticles, biology (with the use of bacteria and plants) with the modern tools and techniques. Nanotechnology involving nanomaterials already have come in applications publicly as stated above. Some of them are still in their infancy stages of development and getting renewed prospects to be used with new properties. As such, continual researches are going on.

b. Many of the upcoming nanomaterials with relevant properties are expected to be used for medicine, molecular biology, food monitoring, bar coding, threat agents monitoring, counterfeit money monitoring, disinfection, environmental monitoring, paints and coating, catalysts for various reactions, agriculture improvements, etc. Besides, dying and fabric industries also expected to find the use of nanoparticles in near future.

c. The advances in biotechnology, genetic engineering, genomics, proteomics and medicine in the fourth coming century mostly depend on the nanotechnology which could provide the tools to study how the tens of thousands of proteins in a cell (the so-called proteome) work together in networks to orchestrate the chemistry of life, which in turn help to understand genetic factors and may provide the ability to control and manipulate DNA and RNA [6].

d. The combination of nanotechnology and optical molecular probes are being developed to identify the molecular alterations that distinguish a diseased cell from a normal cell. Such technologies will ultimately aid in characterizing and predicting the pathologic behavior of diseased cells as well as the responsiveness of cells to drug treatment.

e. The combination of biology and nanotechnology has already led to a new generation of devices for probing the cell machinery and elucidating molecular-level life processes here to far beyond the scope of human inquiry. Tracking biochemical processes within intracellular environments can now be performed in vivo with the use of fluorescent and plasmonic molecular probes and nanosensors. It is now possible to develop nanocarriers for targeted delivery of drugs that have their shells conjugated with DNA constructs for vivo tracking.

f. Some upcoming developments under the techniques are (i) to kill bacterial using gold nanoparticles and infrared light, which may lead to improved cleaning of instruments in hospital settings (ii) the use of quantum dots to treat antibiotic resistant infections (iii) the use of polymer coated iron oxide nanoparticles to treat chronic bacterial infections. So, there are enormous applications in computers to increase memory and speed. It is said that computers will run fast, medicines will cure all diseases, and pollution could be eliminated with the application of nanotechnology. The applications are immense, and it is predicted that it is going to revolutionize the industrial world in the 21stcentury [7].

6.0 IMPLICATIONS AND CHALLENGES

6.1. Implications

Nanotechnology itself may not have any implications or any adverse effect to humanity. But the nanomaterials, in particular nanoparticles, which are the hard-core concern of this technology, might have implications on to the health of living bodies like human, animal, insects etc. and the environment as well. Besides, the nanotechnology itself might have societal implications in the days to come. A brief idea on how these implications might arise is given below:

a. "**Health hazards** for human being as well as living world might arise from the nanomaterials or the materials containing nanoparticles due to their extreme reactivity and mobility. The behavior of nanoparticles is a function of their size, shape and surface reactivity with the surrounding tissue. Apart from what happens if non-degradable or slowly degradable nanoparticles accumulate in organs, another concern is their potential interaction with biological processes inside the body because of their large surface, nanoparticles on exposure to tissue and fluids will immediately absorb onto their surface some of the macromolecules they encounter. Besides, nanodevices also have side or adverse effects specially those, which are used for repairing surgical wounds. Some nanoliquids are also very harmful if they get in contact with human body. Such as nonaluminum, nanosulphur Improved Hydrochloric acid etc. the study, which deals with all the cons of nanotechnology, is known as Nanotoxicology [8].

b. **Environmental** implications arise from the process of manufacturing the nanodevices, which generate some waste. These may be referred to as nanowaste, which may be dangerous because of their extremely small size. These nanowastes can be released to air and can easily penetrate in plants which make them deoxygenated when gets reacted with carbon dioxide. Effects of these nanowaste material is different in various stages of manufacturing sometimes its harmful effects causes death of cats and other little animals because of inhaling toxic gases and by drinking contaminated water or liquid released by the manufacturing plants. For properly evaluating the health hazards each stage of manufacturing must be observed separately and then measures should be taken for reducing the waste [9].

c. The **toxic effects** on human health, there exists some other implication, which is known as **societal implications**. Scientists suggest that social issue of nanotechnology is not very simple that it can be understood by common people easily. Some applications are not suitable for the world for example nanotechnology when stepped into filtration process of gold and diamond, made both more expensive which made people feel little down as their buying power is affected badly.

d. Nanotechnology provides new answers and solutions to the field of medicine, technology, and friction sciences but at the same time, it has created risks for the developing countries such as safe and clean drinking water, reliable energy, clean air, and education. Protection of environment and heath care become a challenge for the developing countries in case of extensive nanotechnology. In this scenario, proper and periodic regulation of nanotech manufacturing plans is needed. It should be kept in mind that to what extend country can afford the damage if caused. People of these third world countries should be properly aware of nanotechnology and its adverse/side effects." [9]

6.2. Perceived Challenges

In the near future, the researcher, scientists, engineers and technologists are going to face some challenges for inventing, synthesizing nanomaterials or nanoparticles and mitigating the implications arises from the nanoproducts as discussed above are summarized below [10]:

a. The integration of nanostructures and nanomaterials into or with macroscopic systems that can interface with people.

b. Building and demonstration of novel tools to study at the nanometer level what is being manifested at the macro level. In that new measurement techniques need to be developed at the nanometer scale and may require new innovations in metrological technology, which is more challenging than ever.

c. All the mathematical models available for macro materials are not applicable to nanoscale materials. They must be developed to predict the behavior of nanomaterials, which are also more challenging than ever.

d. The challenges be to face by the scientists for synthesizing or fabrication and processing of nanomaterials are as under:

(1) Overcome the huge surface energy, as a result of enormous surface area or large surface area to volume ratio.
(2) Ensure all nanomaterials with desired size, uniform size distribution, morphology, crystallinity, chemical composition, and microstructure that altogether result in desired physical properties.
(3) Prevent nanomaterials and nanostructures from coarsening through either Ostwald ripening or agglomeration as time evaluates.

e. The challenges relevant to safety issue of nanotechnology are as follows:

(1) Instruments to assess environment exposure to nanomaterials.
(2) Methods to evaluate the toxicity level of nanomaterials.
(3) Models for predicting the potential impact of new, engineered nanomaterials.
(4) Ways of evaluating the impact of nanomaterials across their life cycle.
(5) Strategic programs to enable risk focused research.

7.0 CONCLUSION

The concept of manipulating and controlling materials at the atomic level is the basement of nanotechnology and finally established it in 1990 after the invention of Carbon nanotube. Nanotechnology is not independent rather a multidiscipline field of study that encompasses almost all the fields of science, engineering and technology. The main focus of this technology is the synthesizing of materials in the nanoscale (10-9 meter). The nanomaterials are of 0-D, 1-D, 2-D and 3-D, which are known as the building blocks of nanotechnology. However, 0-D nanomaterials are of great importance to the scientist, engineers and technologists because of their increased surface-to-volume ratio and they are known as nanoparticles. The size dependent behavior of materials is found to be unique and different from their bulk counter parts.

By the time, around 2500 nano-products have been publicly available. The nanoparticles have numerous applications, which includes electronics, medical, dying fabric industries, diagnostic and pathological test, imaging, water waste management, filtration, drug delivery etc. because of their higher power, lighter weight, higher optical resolution etc. At the same time, they have some adverse effect on to the health of world lives and environment as well. Accordingly, the researches, scientists, engineers and technologists need to face some challenges like integration of nanostructures with macroscopic system, building of novel tools for study, ensuring desired and controlled material properties in nanoscale, toxicity level measurement in the human body when reacts the nanomedicine with the cells, instrumentation to assess environmental exposure of nanomaterials and so on. However, in spite all challenges, it is expected that the nanotechnology will definitely bring the fruits and fortune for the mankind in the 21st century.

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i) The term molecular recognition refers to the specific interaction between two or more molecules through non-covalent bonding such as hydrogen bonding, metal coordination, hydrophobic forces, van-der Waals forces, π-π interactions, halogen bonding, electrostatic and/or electromagnetic effects.

ii) Damascus steel was a type of steel used for manufacturing blades in the near East.

iii) In spintronics, spins are manipulated by both the magnetic and electric fields.

iv) Quantum tunneling or tunneling refers to the quantum mechanical phenomenon where a particle tunnels through a barrier that it classically could not surmount.

v) A pseudo color image (sometimes styled pseudo-color or pseudo color) is derived from a gray scale image by mapping each intensity value to a color according to a table or function.[7]Pseudo color is typically used when a single channel of data is available (e.g. temperature, elevation, soil composition, tissue type, and so on), in contrast to false color which is commonly used to display three channels of data. A typical example for the use of pseudo color is thermography ("thermal imaging"), where infrared cameras feature only one spectral band and show their gray scale images in pseudo color.