Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/11352
DOI URL: http://dx.doi.org/10.21474/IJAR01/11352

RESEARCH ARTICLE

AN EMPIRICAL EXPLORATION OF THE NANOTECHNOLOGY

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Manuscript Info

Manuscript History
Received: 15 May 2020
Final Accepted: 20 June 2020
Published: July 2020

Key words:-
Nanoscience, Nanotubes, Carbon Based Materials, Nanotechnology, Nanofibers, Nanomaterials, Nanoparticles

Abstract

The growth in population and progression of internet services, human dreams, and imagination often give rise to new science and technology. Nanotechnology, a 21st-century frontier, was born out of such dreams. Nanotechnology is defined as the understanding and control of matter at dimensions between 0.1 to 100 nanometers where unique phenomena enable novel applications. Nanotechnology is a new emerging branch of technology, which bears high expectations of its potential to change the world fundamentally. Nanotechnology has helped us innovate at the super microscopic nanoscale to produce previously unavailable materials which are highly flexible, conductive, and durable. These tiny nano-instruments or particles allow us to achieve incredible advances in science, industry and every area of our daily lives. Nanotechnology is a broad term that can be used across all the other scientific fields, such as chemistry, biology, physics, materials science, and engineering. In its most basic form, it can be described as working with things that are small. In this paper, aimed to demonstrate a close-up view about nanotechnology and discusses the implications of it that could impact the human life in the near future. In the end, we are in a nutshell discussing about the different aspects of the nanotechnologies, such as ancient Nanotechnology, Nanotechnology process, and the significance of Nanotechnology, followed by an introduction of several state-of-the-arts present and future areas of Nanotechnology application and Nanotechnology influence our lives.

Introduction:-

Nanotechnology, introduced almost half a century ago, is an active research area with both novel science and useful applications that has gradually established itself in the past two decades [1]. Nanotechnology has become the foundation for remarkable industrial applications and exponential growth. Nanotechnology involves research and technology development at the atomic, molecular, or macromolecular levels in the range of approximately 0.1 to 100 nanometers to provide fundamental understanding of phenomena and materials at the nanoscale. The nanometer scale is about a billionth of a meter. In comparison, a human hair is about 10,000 nanometers [2] in diameter. Nanotechnology operates at the first level of organization of atoms and molecules for both living and anthropogenic systems. This is where the properties and functions of all systems are defined. Such fundamental control promises a broad and a revolutionary technology platform for industry, biomedicine, environmental engineering, safety and security, food, water resources, energy conversion, and countless other areas. Basically nanotechnology is used to

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create structures, devices, and systems that have novel properties, and functions because of their minute size. Nanotechnology [3] and nano engineering stand to produce significant scientific and technological advances in diverse fields including medicine and physiology. In a broad sense, they can be defined as the science and engineering involved in the design, synthesis, characterization, and application of materials and devices whose smallest functional organization in at least one dimension is on the nanometer scale, ranging from a few to several hundred nanometers [4]. A nanometer is one billionth of a meter or three orders of magnitude smaller than a micron, roughly the size scale of a molecule itself (e.g., a DNA molecule is about 2.5nm long while a sodium atom is about 0.2 nm).

Nanotechnology is an important and rapidly growing field of scientific and practical innovation that will fundamentally transform our understanding of how materials and devices interact with human and natural environments [5]. These transformations may offer great benefits to society such as improvements in medical diagnostics and treatments, water and air pollution monitoring, solar photovoltaic energy, water and waste treatment systems, and many others. The burgeoning new field of nanotechnology, [6] opened up by rapid advances in science and technology creates myriad new opportunities for advancing medical science and disease treatment. In the near future, nanotechnology will play an increasingly significant role in the everyday practice of cardiologists, pulmonologists, and hematologists. Nanotechnology and nanoscience focus on materials at the atomic, molecular, [7] and supra molecular level, aiming to control and manipulate these new materials by precisely configuring atoms and molecules, producing novel molecular assemblies and designing systems of self-assembly to create supra molecular devices on the scale of an individual cell and smaller [8].

Nanotechnology is already frequently used in many emerging areas. The age of big data has arrived [9], and scientists are discovering more useful structure & property correlations all the time. Correlations show how structures and properties are related. Big data [10] and the application of multivariate data analytics in the complex world of nano materials is a new direction in Nanoscience and technology, paved with enormous opportunity. Although there exists as range of well-established and reliable statistical methods, there are conceptual barriers that are proving challenging to overcome.

Here, nanotechnology is helping to create ultra-dense memory that will allow us to [11] store this wealth of data. But it’s also providing the inspiration for ultra-efficient algorithms for processing, encrypting, and communicating data without compromising its reliability [12]. The Machine learning (ML) offer new tools to extract new insights from large data sets and to acquire small data sets more effectively. Researchers in nanoscience are experimenting with these tools to tackle challenges in many fields [13]. In addition to ML’s advancement of nanoscience, that is provides the foundation for neuromorphic computing hardware to expand the implementation of ML algorithms [14].

The next revolution in the area of computing will be totally outside the realm of traditional desktop. The Internet of Things (IoT) [15] is regarded as new revolution that is picking up huge popularity in the world of modern wireless telecommunications [16]. The concept of IoT marks high impact on various aspects of everyone’s life as wide range of devices and communication protocols are under rapid development process by industries and researchers in diverse fields like e-health, e-agriculture, e-industry, smart cities, e-military etc. the integration of nanoscale devices with exiting traditional communication networks with High Speed Internet has led to new evolution which is termed as “Internet of Nano-Things (IoNT)” [17]. Internet of Nano-Things (IoNT) will comprise of miniature sensors connected to each other via Nano networks to obtain data from objects [18] Nanotechnology intersects with IoT systems in multiple ways, from the manufacturing of reliable sensors that form an IoT system to the nano processors that compute and process data collected by IoT sensors [19].

Origins of Nanotechnology:

Today, in the young field of nanotechnology, scientists and engineers are taking control of atoms and molecules individually, manipulating them, and putting them to use with an extraordinary degree of precision. Word of the promise of nanotechnology is spreading rapidly, and the air is thick with news of nanotech breakthroughs. Nanotechnology has the potential to completely change the world around us. Although a few scientists had done related work earlier, nanotechnology didn't really get going until the second half of the twentieth century. Credit for inspiring nanotechnology usually goes to Richard Feynman, a brilliant Caltech physicist who later won a Nobel Prize for "fundamental work in quantum electrodynamics." In an after-dinner lecture ("There's Plenty of Room at the Bottom") delivered on the evening of December 29, 1959, Feynman proposed [20] work in a field "in which little has been done, but in which an enormous amount can be done in principle." This new idea demonstrated that Feynman’s hypotheses have been proven correct, and for these reasons, he is considered the father of modern nanotechnology. After fifteen years, Norio Taniguchi, a Japanese scientist was the first to use and define the term “nanotechnology” in 1974 as “nanotechnology mainly consists of the processing of separation, consolidation, and deformation of materials by one atom or one molecule” [21].

In 1987, K. Eric Drexler published his book, “Engines of Creation: The coming era of Nanotechnology”. Aimed at a non-technical audience while also appealing to scientists, [22] Drexler’s book was a highly original work describing a new form of technology based on molecular “assemblers,” which would be able to “place atoms in almost any reasonable arrangement” and there by allow the formation of “almost anything the laws of nature allow.” In 1992 Drexler published Nano systems, a technical work outlining a way to manufacture extremely high-performance machines out of molecular carbon lattice ("diamondoid"). Meanwhile, he was also engaging in policy activism to raise awareness of the implications of the technology; he founded the Foresight Institute in 1986. Engines of Creation created much excitement. The term "nanotechnology" rapidly became popular, and almost immediately its meaning began to shift. By 1992, Drexler was using molecular nanotechnology or molecular manufacturing to distinguish his manufacturing ideas from the simpler product-focused research that was borrowing the word [23]. This research, producing shorter-term results, came to define the field for many observers, and has continued to claim the term Nanotechnology. To avoid confusion, this Press Kit refers to such research as nanoscale technology. Lithography involves the patterning of a surface through exposure to light, ions or electrons, and the deposition of material on to that surface to produce the desired material [24].

The Ancient Nanotechnology:

In the antiquities, nanoparticles were used by the Damascans to create swords with exceptionally sharp edges and the Romans to craft iridescent glassware. The ancient empires of the world are remembered for their impressive large-scale feats of engineering, Macchu Picchu in Peru, the pyramids in Egypt; and the Parthenon in Greece to name a few. But the craftsmen of those eras were also skilled at engineering at the opposite end of the spectrum at the nanoscale. The manipulation of material at the atomic and molecular scale to create new functions and properties sounds like it should be a profoundly modern concept. But artisans from the past also controlled matter at the tiniest scales. By modern-day standards, they were working in a branch of nanotechnology called nanocomposites.

These are bulk materials in which nanoscale particles are mixed to improve the properties of the overall or composite material. Here are a number of relatively famous examples of ancient artifacts which were created using nanocomposites. The Lycurgus cup, for example, is a stunning decorative Roman treasure from about AD 400 shown in figure 1, it is made of a glass that changes color when light is shone through it [25]. The glass contains gold-silver alloyed nanoparticles, which are distributed in such a way to make the glass look green in reflected light but, when light passes through the cup, it reveals a brilliant red.

Fig 1:- The Lycurgus Cup, Illuminated from Outside (left) or from Inside (right).

Afterwards, during the medieval period, the red-color of several stained glasses from churches was also due to the incorporation of gold colloids into the glass [26]. More commonly, yellow stained glasses containing silver nanoparticles have also been produced shown in figure 2.

Fig 2:- Stained Glass Window from the Sainte-Chapelle in Paris.

Furthermore, the use of gold nanoparticles as red-colorant was not only limited to glassmakers, since some pieces of porcelain containing red and pink enamels can also be mentioned [27]. For example, the recipe of the Purple of Cassius has reached China during the Qing Dynasty (eighteenth century), almost certainly conveyed by Jesuit missionaries, and has been successfully used for the production of the famous ‘‘Famille Rose’’ porcelain shown in figure 3.

Fig 3:- The ‘‘Famille Rose’’ Guimet Museum in Paris.

Nanotechnology:

The prefix ‘nano’ is derived from the Greek word nannos, meaning “very short man.” Most of the measurement prefixes used today originates from Greek and Latin words used in measurements. The nanoscale, then, is the size scale at which nanotechnology operates. Though we have a lower limit on this scale size (the size of one atom), pinning down an upper limit on this scale is more difficult. A useful and well accepted convention is that for something to exist on the nanoscale, at least one of its dimensions (height, width, or depth) must be less than about 100 nanometers. In fact, it is these limits to the nanoscale that the National Nanotechnology Initiative (NNI) uses

[28] for its definition of nanotechnology for instance, "Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nm, where unique phenomena enable novel applications" shown in figure 4. It is useful to add two other statements to form a complete definition. First, nanotechnology includes the forming and use of materials, structures, devices, and systems that have unique properties because of their small size [29]. Also, nanotechnology includes the technologies that enable the control of materials at the nanoscale. Nanotechnology literally means any technology done on a nanoscale that has applications in the real world. The Nanotechnology encompasses the production and application of physical, chemical, and biological systems at scales ranging from individual atoms or molecules to submicron dimensions, as well as the integration of the resulting nanostructures into larger systems. Nanotechnology is likely to have a profound impact on our economy and society in the early 21st century. We can distinguish mainly three types of nano materials. Indeed, if nano-objects have all their three dimensions lower than a few hundred nanometres, they are called ''nanoparticles''. If only two dimensions are lower than a few hundred nanometres, they correspond to ''nanotubes'' or ''nanowires'' whereas if only one dimension is lower than a few hundred nanometers, they correspond to ''nanofilms'' or ''nanolayers''. According to the required applications, these nano materials can be made up of different elements, metals namely gold or silver nanoparticles, metal oxides namely titanium dioxide nanoparticles, semiconductors, namely silicon, or carbon, namely carbon nanotubes.

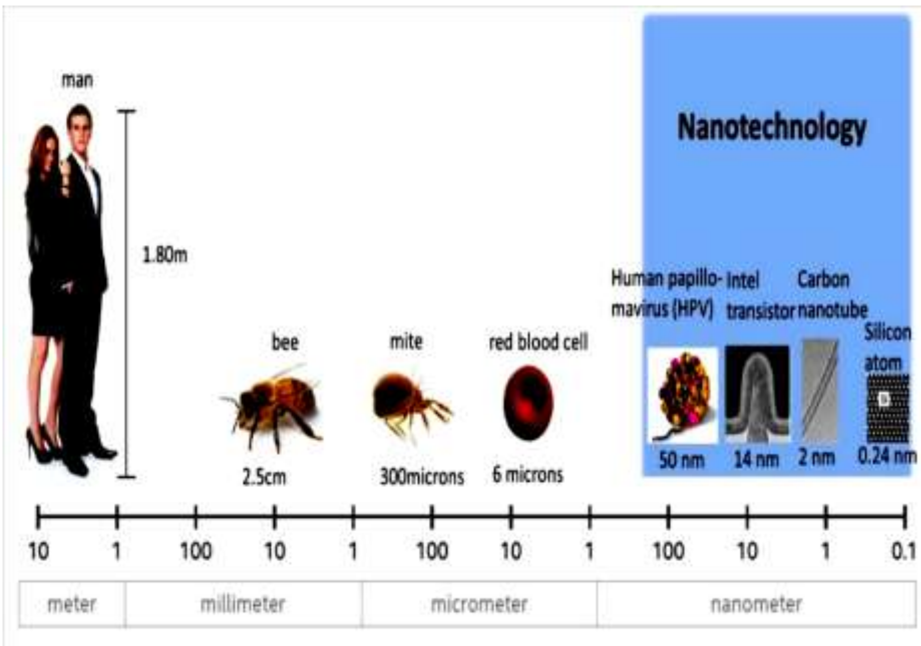

Fig 4:- Scale of Dimensions from Meter Down to Nanometer in Nanotechnology.

Nanotechnology Process:

The general concept of top down and bottom up and different process adapted to synthesized nanoparticles [30] by using these techniques are summarized in shown in figure 5. In 1986, K. Eric Drexler published the first book on nanotechnology "Engines of Creation, The Coming Era of Nanotechnology", which led to the theory of "molecular engineering" becoming more popular. Drexler described the build-up of complex machines from individual atoms, which can independently manipulate molecules and atoms and thereby produces self-assembly nanostructures [31]. Nanoscale manufacturing can occur either from the top down or the bottom up process. Top-down manufacturing starts with bulk materials which are then whittled down, until the features that are left are nanoscale. For instance, crystal line drugs may be milled until the individual particle sizes are 100 nm, or smaller.

The top-down process is essentially the breaking down of bulk material to get nano-sized particles. This can be achieved by using advanced techniques such as precision engineering and lithography which have been developed and optimized by industry during recent decades. Precision engineering supports the majority of the micro-electronics industry during the entire production process, and the high performance can be achieved through the use of a combination of improvements. At this size, the particles have a much larger surface area in relation to volume than would more conventional micro scale particles. This permits them to dissolve much faster, which is critical for certain drugs that are not very soluble in water.

The Bottom-up process atom-by-atom or molecule-by-molecule by physical and chemical methods which are in a nanoscale range (1 nm to 100 nm) using controlled manipulation of self-assembly of atoms and molecules. The chemical synthesis is a method of producing rough materials which can be used either directly in product in their bulk disordered form, or as the building blocks of more advanced ordered materials. Self assembly is a bottom-up process in which atoms or molecules organize themselves into ordered nanostructures by chemical-physical interactions between them. Positional assembly is the only technique in which single atoms, molecules or cluster can be positioned freely one-by-one [32]. Bottom-up manufacturing involves creating objects or materials from individual atoms or molecules and then joining them together in a specific fashion.

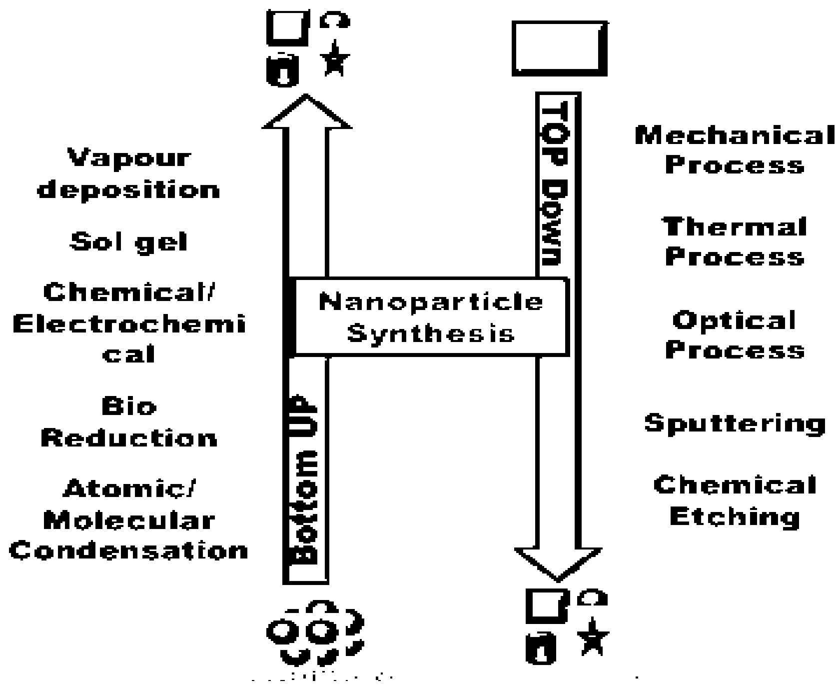

Fig 5:- The Top Down and Bottom up Process Dissimilar Procedure for Nanoparticle Synthesis.

Significance of Nanotechnology:
Nanotechnology is helping to considerably improve, even revolutionize, many technology and industry sectors, information technology, homeland security, medicine, transportation, energy, food safety, and environmental science, among many others.

Nanotechnology in Agriculture:
Agriculture is the use of biological processes to produce food and many other desired products that are beneficial and essential to man by breeding of crops and animals. Agriculture is considered as the oldest area which is highly essential for life of earth. Agriculture is vital to human sustenance and it is an important economic driver in most developing countries [33]. As it is with many other fields that squarely depend on biological processes, nanotechnology possesses great potential to revolutionize agriculture because biological systems are basically composed of nanostructured materials and biological processes depend significantly on functionality occurring at the nano level. Currently, the application of nanotechnology in agriculture concerns the use of nanosized particles with extraordinary properties to increase the productive capacity of crops and farm animals. Soil nutrient is a key factor that determines the quality and quantity of the crop.

Nanotechnology in Water Purification:
The availability of clean, safe water is fundamental to the sustenance of life and it is important to health, environment, and economy. As the global population increases, the demand for water increases and an adequate supply of water becomes great concern especially, in water-stressed areas, [34] leading to the exploration of

unconventional sources of water such as seawater and wastewater. The current water purification technologies are therefore gradually becoming inadequate for meeting the need for safe water. Nanomaterials are well suited for water purification, disinfection, and wastewater treatment applications as they have as large specific surface area, high reactivity, high degree of functionalization, size dependent properties, affinity for specific target contaminants, etc. membranes and filters synthesized using nanomaterials have selective permeability, good flux rates, increased durability, reliability in purification and reusability, and thus are energy saving and cost effective.

Nanotechnology in Healthcare:
The application of nanotechnology in health care is known as nanomedicine. The nanotechnology, in [35] the forms of nanomedicine, nanoimplants, nanobiosensors along with the internet of nano things (IoNT), has the potential to bring a revolutionizing advancement in the field of medicine and healthcare services. Applications of nanotechnology in medicine include prevention, diagnosis, and treatment, follow-ups of diseases, drug delivery, therapy and disinfection [36]. Tracing diseases to abnormalities at the molecular level through the knowledge of molecular genomics and proteomics theoretically increases the chances of early-stage diagnosis and the possibility of commencing treatment even prior to the appearance of the preliminary symptoms of a disease. Nanotechnology has the capability of employing molecular genomics and proteomics-based discoveries to achieve this [37].

Nanotechnology in Transportation:
Transportation involves the conveyance of people, goods and other things over macroscale distances. The role of transportation in economic development cannot be overemphasized. An effective transportation system requires a sustainable facility for the conveyance of goods and people and is expected to be safe, durable and economical. There are several opportunities for the application of nanotechnology to [38] adequately meet these requirements in the transportation industry. Nanotechnology is playing vital role in enhancing the battery life. So use of nanostructure materials in battery design is increasing day by day. This enables battery to become effectual in many applications Lithium- ion batteries (LIBs) are the best choice as they have advantages such as high energy density, high discharge power, and long service life [39].

Nanotechnology in Energy:
Nanotechnology is being used and is being considered for increased sustainability of the energy sector. Nanotechnology has a lot of energy applications which is increasing day by day. Nanotechnology has the capability to provide cleaner and more efficient supplies and usage of energy. Even though not all applications of nanotechnology in the energy sector necessarily affect energy transmission directly; they, however, possess the potential for reducing the need for electricity, natural gas and other fossil fuels. In the energy sector, nanotechnology plays significant roles in the areas of lighting, heating, renewable energy, energy storage, fuel cells, and hydrogen power generation and storage [40]. The Nanotechnology enabled high-power and high-energy density microelectronics, power electronics, energy sources, and energy storage solutions. These energy systems are used in various applications including aerospace, biomedical, communication, electronics, micro-electromechanical systems (MEMS), robotics, etc.

Nanotechnology in Electronics:
Nanotechnology has greatly contributed to major advances in computing and electronics, leading to faster, smaller, and more portable systems that can manage and store larger and larger amounts of information. Transistors, the basic switches that enable all modern computing, have gotten smaller and smaller through nanotechnology. At the turn of the century, a typical transistor was 130 to 250 nanometers in size [41]. In 2014, Intel created a 14 nanometer transistor, then IBM created the first seven nanometer transistor in 2015, and then Lawrence Berkeley National Lab demonstrated a one nanometer transistor in 2016 Smaller, faster, and better transistors may mean that soon your computer's entire memory may be stored on a single tiny chip.

Using magnetic random access memory (MRAM), computers will be able to "boot" almost instantly. The nanometer-scale magnetic tunnel junctions and can quickly and effectively save data during a system shutdown or enable resume-play features. Again ultra-high definition displays and televisions are now being sold that use quantum dots to produce more vibrant colors while being more energy efficient. The flexible, bendable, foldable, roll able and stretchable electronics are reaching into various sectors and are being integrated into a variety of products, including wearable, medical applications, aerospace applications, and the Internet of Things. Flexible electronics have been developed using, for example, semiconductor nanomembranes for applications in smart phone and e-reader displays. Other nanomaterials like graphene and cellulosic nanomaterials are being used for various types of flexible electronics to enable wearable and "tattoo" sensors, photovoltaics that can be sewn onto clothing, and electronic paper that can be rolled up. Making flat, flexible, lightweight, non-brittle, highly efficient electronics opens the door to countless smart products. Other computing and electronic products include Flash memory chips for smart phones and thumb drives; ultra-responsive hearing aids; antimicrobial & antibacterial coatings on keyboards and cell phone [42] casings, conductive inks for printed electronics for RFID & smart cards & smart packaging, flexible displays for e-book readers. Nanoparticle copper suspensions have been developed as a safer, cheaper, and more reliable alternative to lead-based solder and other hazardous materials commonly used to fuse electronics in the assembly process.

Nanotechnology in Blockchain & Pattern Recognition:

A Blockchain is a type of database that is tamper proof. Data stored in a Blockchain cannot be changed in other words, the technical term is immutable [43], it can be shared among multiple users, and significantly the composition of the data stored is agreed to by multiple users of the Blockchain before it can be stored (this process is known as consensus) [44] shown in figure 6. The combination of Blockchain and nanotechnology can be applied to a particularly challenging aspect of supply chain management, namely the huge global criminal marketplace in counterfeit goods, which hurts business profits, impacts brand trust and undermines customer relationships. The Quantum Materials Corp. developed nanomaterials called quantum dots over the past decade. Quantum dots are nanoscale semiconductor particles that possess notable and extremely useful optical and electrical properties [45]. They measure from 1,000 to 100,000 atoms in size and they generate light when energy is applied to them or generate energy when light is applied.

In this technique creates in commercial quantities quantum dots that can be finely tuned to emit predetermined wavelengths of light (in both the visible and non-visible spectrums) with the ability to create billions of unique [46] optical signatures. When the quantum dot signature of a product is scanned (via a hand-held scanner or an app on a Smartphone), a digital representation is created that is stored on our secure and tamper-proof Blockchain platform. It is this platform that allows for tracking of products providing visibility among all participants in their supply chain from manufacture to customer purchase.

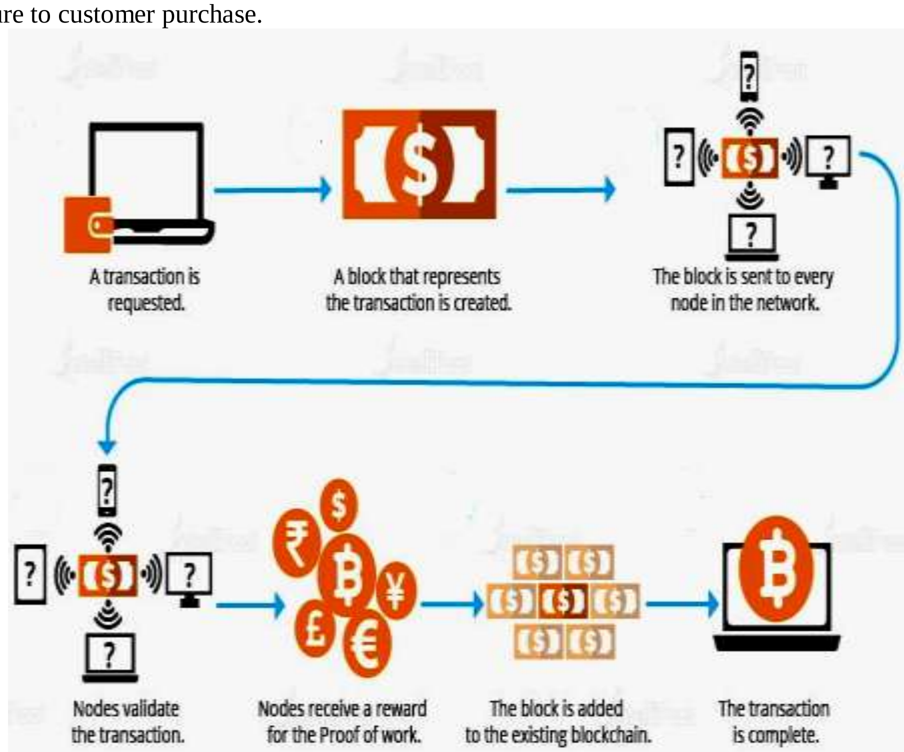

Fig 6:- The How Blockchain Work.

A pattern recognition system, comprising a neural network formed utilizing nanotechnology and a pattern input unit, which communicates with the neural network, wherein the neural network processes data input via the pattern input unit in order to recognize data patterns thereof [47]. Such a pattern recognition system can be implemented in the context of a speech recognition system and other pattern recognition systems, such as visual and imaging recognition systems.

Categorizing of Nanomaterials:
Nanomaterials are material science based approach to nanotechnology. All the materials that are used for nanotechnology are studied and their properties are applied according to their application. Most of the nanomaterials used in nanotechnology are smaller than 1 µm. Nanomaterials can be categorizing into different types according to the size, morphology, physical and chemical properties [48]. There are many types of intentionally produced nanomaterials, and a variety of others are expected to appear in the future. Nanomaterials can be categorizing primarily into two types, first Natural and second artificially fabricated. In Natural nanomaterials these include nanomaterials that exist in biological systems, for instance viruses (capsid), substances in our bone matrix. In artificial nanomaterials these are the ones that are fabricated by different experiments.

Carbon Materials in Nanotechnology:
These nanomaterials are composed mostly of carbon, most commonly taking the form of a hollow spheres, ellipsoids, or tubes. Spherical and ellipsoidal carbon nanomaterials are referred to as fullerenes, while cylindrical ones are called nanotubes. These particles have many potential applications, including improved films and coatings, stronger and lighter materials, and applications in electronics.

Nanotubes in Nanotechnology:
Nanotubes are nanoparticles of carbon discovered in 1991. Nanotubes have more importance due to their characteristics and use extensive applications in industrial, scientific, medical, and bio-electronic devices. Nanotubes are able to be defined as a carbon nanotube where a graphite segment is folded around the axis of a cylindrical shape, where atoms are linked with each end of the slide to close the tube [49]. The tube ends might be in the form of a hemisphere. It might also be separate atoms tube wall, which is termed in this case nanotubes and single wall nanotube (SWNT), or binary or more which is termed multi-wall tubes (MWNT), with tube diameter, sorts from less than one nanometer to 100 nanometers, but it has a length of up to 100 micrometers to form Nanowires as shown in figure 7.

Fig 7:- The Models for Carbon Nanotubes.

Ceramic Nanomaterials in Nanotechnology:
The ceramic nanomaterials are inorganic solids made up of oxides, carbides, carbonates, and phosphates. These nanoparticles have high heat resistance and chemical inertness. They have applications in photo catalysis, photo degradation of dyes, drug delivery, and imaging. The characteristics of ceramic nanoparticles like size, surface area, porosity, surface to volume ratio, etc, they perform as a good drug delivery agent. These nanoparticles have been used effectively as a drug delivery system for a number of diseases like bacterial infections, glaucoma, cancer, etc.

Fullerenes in Nanotechnology:
The fullerenes are actually grapheme sheets rolled in the form of spheres and are actually a class of allotropes of carbon. A main example of fullerene is carbon nanotubes. They are known for their mechanical strength and their good electrical conductivity. Fullerenes are mainly used in the medical field as they are known for binding certain types of antibiotics to the structure of resistant bacteria. They are also found to be resistant against melanoma, at type of cancer cell. All these are possible only because of the good physical and chemical properties of fullerenes. They are also known for their high resistance and superconductivity properties. Thus, they also find great applications as light-activated antimicrobial agents. Fullerenes are obtained by inserting a large amount of current in between two very close graphite electrodes in an atmosphere that is inert in nature.

Metal Materials in Nanotechnology:
These nanomaterials contain quantum dots, nanogold, nanosilver and metal oxides, such as titanium dioxide. A quantum dot is a closely packed semiconductor crystal comprised of hundreds or thousands of atoms, and whose size is on the order of a few nanometers to a few hundred nanometers. The changing the size of quantum dots changes their optical properties.

Dendrimers in Nanotechnology:
These nanomaterials are nanosized polymers built from branched units. The surface of a dendrimer has numerous chain ends, which can be tailored to perform specific chemical functions. This property could also be useful for catalysis. The three dimensional dendrimers contain interior cavities into which other molecules could be placed, and they may be useful for drug delivery.

Composites in Nanotechnology:
The composites combine nanoparticles with other nanoparticles or with larger, bulk-type materials. The composites may be any combination of metal based, carbon based or polymer based nanomaterials with any form of metal, ceramic, or polymer bulk materials. Nanoparticles, such as nanosized clays, are already being added to products ranging from auto parts to packaging materials, to enhance mechanical, thermal, barrier, and flame-retardant properties.

Unique Properties in Nanotechnology:
The unique properties of these various types of intentionally produced nanomaterials give them novel electrical, catalytic, magnetic, mechanical, thermal, or imaging features that are highly desirable for applications in commercial, medical, military, and environmental sectors. These materials may also find their way into more complex nanostructures and systems. As new uses for materials with these special properties are identified, the number of products containing such nanomaterials and their possible applications continues to grow.

The Semiconductor Nanoparticles in Nanotechnology:
The semiconductor nanoparticles have properties like those of metals and non-metals. They are found in the periodic table in groups II-VI, III-V, or IV-VI. These particles have wide band gaps, which on tuning show different properties. They are used in photo catalysis, electronics devices, photo-optics, and water splitting applications.

The Polymeric Nanoparticles in Nanotechnology:
The polymeric nanoparticles are organic based nanoparticles. Depending upon the method of preparation, these have structures shaped like nanocapsular or nanospheres. A nanosphere particle has a matrix-like structure whereas the nanocapsular particle has core-shell morphology. In the former, the active compounds and the polymer are uniformly dispersed whereas in the latter the active compounds are confined and surrounded by a polymer shell. They have applications in drug delivery and diagnostics. The drug deliveries with polymeric nanoparticles are highly biodegradable and biocompatible.

Nanowires in Nanotechnology:
In Nanowires, the wire diameter may be less than one nanometer. The electrons are limited measured toward both sides which make it occupy exact levels of energy, which vary from those extensive levels found in volumetric of the article. Because of its submission of quantitative restriction built on quantum mechanics, it will have electrical conductivity which take exact values almost equal to complications amount to 12.9 kilo-ohm 1, which does not exist in nature but can be urbanized in the laboratory, where the metallic ones (nickel, silver, platinum), semiconductor and separation (silicates, titanium oxide), including organic molecular wires (DNA) can be used. The figure 8 shows

Nanoscale wires scanning with the electron microscope. This can be done, to tie accurate electronic components inside a small circle or the work of bilateral links, as well as establishing the logical electronic circuit may be utilized for the manufacture of the digital computer in the future [50].

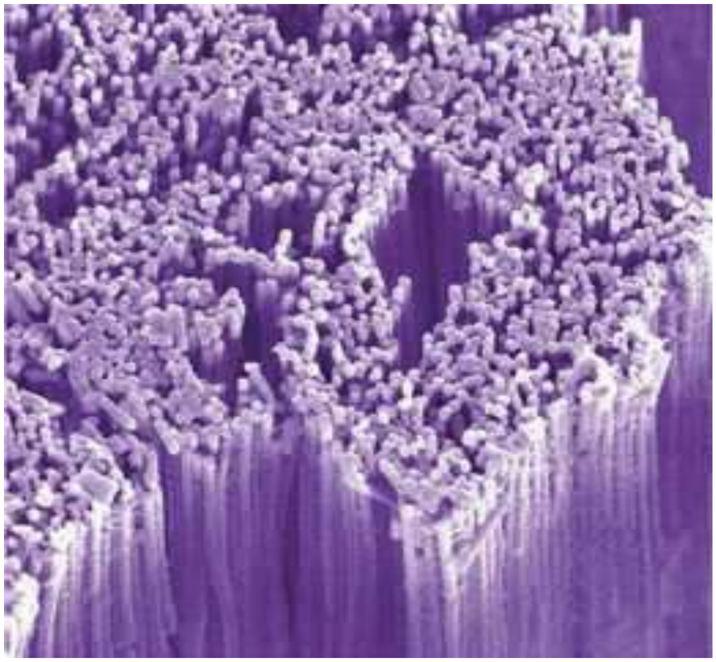

Fig 8:- The Nanoscale Wires.

Lipid Nanoparticles in Nanotechnology:
The lipid nanoparticles are generally spherical in shape with a diameter ranging from 10 to 100nm. It consists of a solid core made of lipid and a matrix containing soluble lipophilic molecules [51]. The external core of these nanoparticles is stabilized by surfactants and emulsifiers. These nanoparticles have application in the biomedical field as a drug carrier and delivery and RNA release in cancer therapy.

Smart Living in Nanotechnology:
We live in an ongoing digital media revolution where data holds the key too many of the next generation technology within urban environments. Nanotechnology allows us to harness this data and educate our people in real time. Our homes, clothes and even our bodies will be able to harness this nano-enabled data in real time so that we can be smart with our health, energy, food, transport, infrastructure, water resources, education, security, communications, and finances. Even our culture and heritage will be protected as well as our environment. The unique properties of nanotechnology are even being used to protect some of the world heritage sites and ancient artifacts.

Nanotechnology Influence Our Lives:
Nanotechnology influences our lives on a daily basis. Nanotechnology is so important because it could have the potential to solve many of humanity's problems. Faster, smaller, and more powerful computers that consume far less power, with longer-lasting batteries. Circuits made from carbon nanotubes could be vital in maintaining the growth of computer power, allowing Moore's Law to continue. The more accurate medical diagnostic equipment. Lab-on-a-chip technology enables point-of-care testing in real time, which speeds up delivery of medical care. Nanomaterials surfaces on implants improve wear and resist infection. Nanoparticles in pharmaceutical products improve their absorption within the body and make them easier to deliver, often through combination medical devices. Nanoparticles can also be used to deliver chemotherapy drugs to specific cells, such as cancer cells. Improved vehicle fuel efficiency and corrosion resistance by building vehicle [52] parts from nanocomposites materials that are lighter, stronger, and more chemically resistant than metal. Nanofilters remove nearly all airborne particles from the air before it reaches the combustion chamber, further improving gas mileage. Nanoparticles or nanofibers in fabrics can enhance stain resistance, water resistance, and flame resistance, without a significant increase in weight, thickness, or stiffness of the fabric. For example, “nano-whiskers” on pants make them resistant to water and stains.

In terms of leaders in the field, the most 'newsworthy' would be Elon Musk's neural ink. Founded in 2016, neural ink, like most of Musks ventures, aims high with futuristic innovation that creates industry innovation. Don't let the simplistic website fool you, the minds behind this project have formed a 'super-think tank', with all the parties involved working seamlessly together. Neural ink has been described by some as a brain-machine interface development project. And it's considered his biggest project yet. If Musk were to succeed with this crazy startup, it would make it possible for brains to communicate with computers using thought. Synthetic engineering uses robotics, AI, and other sophisticated software to redesign proteins to do specific jobs. It's attracting many VC's, with the top synthetic biology companies raking in $1.7 billion in 2017. Needless to say, it's an industry to keep an eye on. If synthetic biology reaches new heights, it has the possibility of transforming industry related to physical materials, for example, the consumer goods market, industrial chemicals, and medicine.

The water filters that are only 15-20 nanometers wide can remove nano-sized particles, including virtually all viruses and bacteria. These cost-efficient, portable water treatment systems are ideal for improving the quality of drinking water in emerging countries.

In carbon nanotubes have a variety of commercial uses, including making sports equipment stronger and lighter weight. For example, a tennis racket made with carbon nanotubes bends less during impact, and increases the force and accuracy of the delivery [51]. Nanoparticle-treated tennis balls can keep bouncing twice as long as standard tennis balls. The most sunscreens today are made from nanoparticles that effectively absorb light, including the more dangerous ultraviolet range. They also spread more easily over the skin. These same nanoparticles are also used in food packaging to reduce UV exposure and prolong shelf life.

Many drink bottles are made from plastics containing nanoclays, which increase resistance to permeation by oxygen, carbon dioxide, and moisture. This helps retain carbonation and pressure and increases shelf life by several months. Thanks to nanotechnology, a huge variety of chemical sensors can be programmed to detect a particular chemical at amazingly low levels, for example, a single molecule out of billions. This capability is ideal for surveillance and security systems at labs, industrial sites, and airports. On the medical front, nanosensors can also be used to accurately identify particular cells or substances in the body.

The wearable fitness technology means we can monitor our health by strapping gadgets to ourselves. There are even prototype electronic tattoos that can sense our vital signs. But by scaling down this technology, we could go further by implanting or injecting tiny sensors inside our bodies shown in figure 9. This would capture much more detailed information with less hassle to the patient, enabling doctors to personalize their treatment.

The possibilities are endless, ranging from monitoring inflammation and post-surgery recovery to more exotic applications whereby electronic devices actually interfere with our body's signals for controlling organ function. Although these technologies might sound like a thing of the far future, multi-billion healthcare firms such as GlaxoSmithKline are already working on ways to develop so-called electroceuticals.

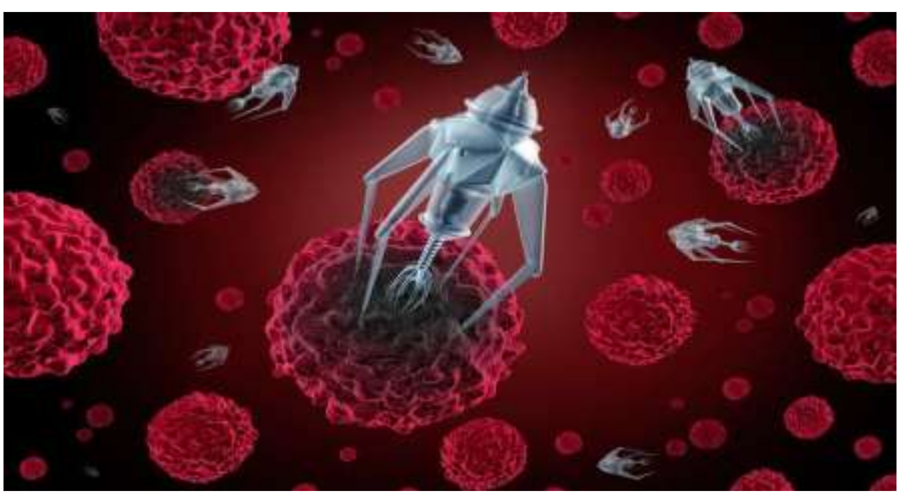

Fig 9:- The Medical Nanobots.

Nanotechnology improves existing industrial processes, materials, and applications by scaling them down to the nanoscale in order to ultimately fully exploit the unique quantum and surface phenomena that matter exhibits at the nanoscale. This trend is driven by companies' ongoing quest to improve existing products by creating smaller components and better performance materials, all at a lower cost. A prime example of an industry where nanoscale manufacturing technologies are employed on a large scale and throughout is the semiconductor industry where device structures have reached the single nanometers scale. Your Smartphone, smart watch or tablet all are containing billions of transistors on a computer chip the size of a finger nail. Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering.

The Controversy in Nanotechnology:

Ethics promotes the responsible development of technology. In light of the present understanding, nanomaterials and their applications may possess potential inherent hazards. The probable hazards depend on the particular nanomaterials and applications [52]. It is very necessary to properly conduct examinations on the potential consequences of nanotechnology principles, processes, and applications to identify instances of nonconformity to safety standards and regulations. At this time, the principal challenge is basically related to the development and validation of methods & instruments for detecting, characterizing and analyzing nanomaterials, assessment of exposure to nanomaterials and the development [53] of comprehensive information on the risks connected with nanomaterials and nanotechnologies. According to Sandler, ethics in nanotechnology ensure that what is meant by enhancement of lifestyle, justice, and sustainability are clarified [54]. Through ethics, ways of achieving the goals of nanotechnology and the hindrances to achieving them are identified, restrictions on the pursuit of the goals are set out, instruments and resources for making ethically substantiated judgments are established, and assessment standards for potential nanotechnologies are also developed.

Societal Controversy in Nanotechnology:

The social implications of nanotechnology encompass many areas, which include: privacy, security, environment, and ethical questions, such as the interactions between humans and nanotechnology engineering medical devices and applications as well as a wide range of consumer products. Many of the privacy risks regarding the technology fall under the development of nanotechnology intended to aid in surveillance of people and places.

Economic Influence of Nanotechnology:

In most countries, the economic value of nanotechnology is measured in terms of employment, education, research activity, and commercialization of products and processes. These metrics can vary widely. It is difficult to define the metrics of nanotechnology. We can count patents, but not all patents are commercialized. We can evaluate research by counting published articles and papers, but research varies widely in its importance and value. Nanotechnology degrees earned by university students provide a useful metric, along with research projects and outputs, to gauge the value of academic activity. However, economic metrics are more complex. Evaluating the return on investment from nanotechnology investments is much more difficult for government agencies and policymakers. Often, a government agency is asked to justify the value derived from millions or billions of dollars in nanotechnology investments. These investments can be evaluated in terms of job creation, reduction of manufacturing costs, new company formation, contribution to export industries, and creation of new products or services -but rarely is there a straight line metric that translates public funding of nanotechnology initiatives directly into commercial value. Taking into account the above considerations, we will try to assess the business potential of nanotechnology applications, based on nanomaterials (nanoparticles, nanotubes, nanostructured materials and nanocomposites), nano tools (nanolithography tools and scanning probe microscopes) and nano devices (nanosensors and nanoelectronics) that, according to a study issued by BCC Research in 2016, should reach $90.5 billion by 2021 from $39.2 billion in 2016 at a compound annual growth rate (CAGR) of 18.2%, from 2016 to 2021

Environment Contention:

In free form nanoparticles can be released in the air or water during production (or production accidents) or as waste byproduct of production, and ultimately accumulate in the soil, water, or plant life. In fixed form, where they are part of a manufactured substance or product, they will ultimately have to be recycled or disposed of as waste.

Privacy Contention:

Nanotechnology is likely to lead to smaller, faster, cheaper computers. The notion of ‘ubiquitous computing’ with all the benefits it promises becomes much easier to develop with nano-based processors and memory. The proliferation of powerful computers, however, will make it even easier to compile and process databases of personal information. Current privacy regulations may serve to regulate the large databases maintained by credit companies and consumer manufacturing companies, although even this claim is questioned [55]. What happens when, for instance, any individual can use a tiny video camera to record people passing into a particular store, face-recognition software to identify those people, publicly-available databases to find those people’s ad-dresses and personal data, and then create marketing pitches based on the stores they have entered? Who will control access to information? In the field of genetics, many laws have been introduced, but not always implemented, to protect the privacy of medical records so that, for instance, insurance companies will not be privy to individual health profiles. But is that fair to the investors in insurance companies, whose business model is based on the assumption that risks can be fairly identified and apportioned across groups? How can the claims and needs of individuals, corporations, other groups, and the state be adjudicated.

Present and Future Areas of Nanotechnology Application:
In this section, we are discussing the present and future areas of Nanotechnology application.

Sunglasses:
Using protective and antireflective ultrathin polymer coatings. Nanotechnology also offers scratch-resistant coatings based on nanocomposites that are transparent, ultra-thin, and simple to care for, well suited for daily use and reasonably priced.

Textiles:
Textiles can incorporate nanotechnology to make practical improvements to such properties as wind proofing and waterproofing, preventing wrinkling or staining, and guarding against electrostatic discharges. The windproof and waterproof properties of one ski jacket, for example, are obtained not by a surface coating of the jacket but by the use of nanofibers. Future projects include clothes with additional electronic functionalities, so-called “smart clothes” or “wearable electronics”. These could include sensors to monitor body functions or release drugs in the required amounts, self-repairing mechanisms or access to the Internet.

Sports Equipment:
Sports equipment manufacturers are also turning to nanotech. A high-performance ski wax, which produces a hard and fast-gliding surface, is already in use. The ultra-thin coating lasts longer than conventional waxing systems. Tennis rackets with carbon nanotubes have increased torsion and flex resistance. The long-lasting tennis balls are made by coating the inner core with clay polymer nanocomposites and have twice the lifetime of conventional balls.

Sunscreens and Cosmetics:
The sunscreens and cosmetics based on nanotech are already widely used. Customers like products that are translucent because they suggest purity and cleanliness, and L’Oreal discovered that when lotions are ground down to 50 or 60 nms, they let light through. For sunscreens, mineral nanoparticles such as titanium dioxide offer several advantages. Traditional chemical UV protection suffers from its poor long-term stability. Titanium dioxide nanoparticles have a comparable UV protection property as the bulk material, but lose the cosmetically undesirable whitening as the particle size is decreased. For anti-wrinkle creams, a polymer capsule is used to transport active agents like vitamins.

Televisions:
Televisions using carbon nanotubes could be in use by late 2006 according to [56] Samsung. Manufacturers expect these "field effect displays," (FED) to consume less energy than plasma or liquid crystal display (LCD) sets and combine the thinness of LCD and the image quality of traditional cathode ray tubes (CRT). The electrons in an FED are fired through a vacuum at a layer of phosphorescent glass covered with pixels. But unlike CRT, the electron source, the carbon, is only 1 to 2 mm from the target glass instead of 60cm with CRT, and, instead of one electron source, the electron gun, there are thousands. FED contains less electronics than LCD and can be produced in a wide range of sizes. Toshiba, for example, will offer screen sizes of at least 50 inches, around 130 cm.

Electronics and Communications:
Using nanolayers and dots, flat-panel displays, wireless technology, new devices and processes across the entire range of communication and information technologies, factors of thousands to millions improvements in both data

storage capacity and processing speeds and at lower cost and improved power efficiency compared to present electronic circuits.

Chemicals and Materials:
The catalysts that increase the energy efficiency of chemical plants and improve the combustion efficiency of motor vehicles, super-hard and tough drill bits and cutting tools, "smart" magnetic fluids for vacuum seals and lubricants.

Pharmaceuticals and Life Sciences:
Nanostructured drugs, gene and drug delivery systems targeted to specific sites in the body, bio-compatible replacements for body parts and fluids, self diagnostics for use in the home, sensors for labs-on-a-chip, material for bone and tissue regeneration.

Manufacturing:
Nanopowders are sintered into bulk materials with special properties that may include sensors to detect incipient failures and actuators to repair problems, chemical-mechanical polishing with nanoparticles, self-assembling of structures from molecules, bio-inspired materials and bio-structures.

Energy Technologies:
New types of batteries, artificial photosynthesis for clean energy, quantum well solar cells, safe storage of hydrogen for use as a clean fuel, energy savings from using lighter materials and smaller circuits.

Space Exploration:
The lightweight space vehicles, economic energy generation and management, ultra small and capable robotic systems.

Environment:
The selective membranes that can filter contaminants or even salt from water, nanostructured traps for removing pollutants from industrial effluents, characterisation of the effects of nanostructures in the environment, maintenance of industrial sustainability by significant reductions in materials and energy use, reduced sources of pollution, increased opportunities for recycling.

National Security:
Detectors and detoxifiers of chemical and biological agents, dramatically more capable electronic circuits, hard nanostructured coatings and materials, camouflage materials, light and self repairing textiles, blood replacement, miniaturised surveillance systems.

Drug Delivery:
This may be the most profitable application of nanotechnology in medicine, and even generally, over the next two decades. Drugs need to be protected during their transit through the body to the target, to maintain their biological and chemicals properties or to stop them damaging the parts of the body they travel through. Once a drug arrives at its destination, it needs to be released at an appropriate rate for it to be effective. This process is called encapsulation, and nanotechnology can improve both the diffusion and degradation characteristics of the encapsulation material, allowing the drug to travel efficiently to the target and be released in an optimal way. Nanoparticle encapsulation is also being investigated for the treatment of neurological disorders to deliver therapeutic molecules directly to the central nervous system beyond the blood-brain barrier, and to the eye beyond the blood-retina barrier.

Repair and Replacement:
Damaged tissues and organs are often replaced by artificial substitutes, and nanotechnology offers a range of new biocompatible coatings for the implants that improves their adhesion, durability and lifespan. New types of nanomaterials are being evaluated as implant coatings to improve interface properties. For example, nano polymers can be used to coat devices in contact with blood (e.g. artificial hearts, catheters) to disperse clots or prevent their formation. Nanomaterials and nanotechnology fabrication techniques are being investigated as tissue regeneration scaffolds. The ultimate goal is to grow large complex organs. Examples include nanoscale polymers moulded into heart valves, and polymer nanocomposites for bone scaffolds. Commercially viable solutions are thought to be 5 to

10 years away, given the scientific challenges related to a better understanding of molecular & cell biology and fabrication methods for producing large three dimensional scaffolds.

Hearing and Vision:
Nano and related micro technologies are being used to develop a new generation of smaller and potentially more powerful devices to restore lost vision and hearing. One approach uses a miniature video camera attached to a blind person’s glasses to capture visual signals processed by a microcomputer worn on the belt and transmitted to an array of electrodes placed in the eye. Another approach uses of a sub retinal implant designed to replace photoreceptors in the retina. The implant uses a microelectrode array powered by up to 3500 microscopic solar cells. For hearing, an implanted transducer is pressure-fitted onto a bone in the inner ear, causing the bones to vibrate and move the fluid in the inner ear, which stimulates the auditory nerve. An array at the tip of the device uses up to 128 electrodes, five times higher than current devices, to simulate a fuller range of sounds. The implant is connected to a small microprocessor and a microphone in a wearable device that clips behind the ear. This captures and translates sounds into electric pulses transmitted by wire through a tiny hole made in the middle ear.

Nanoseeds:
In Thailand, scientists at Chiang Mai University's nuclear physics laboratory have rearranged the DNA of rice by drilling a nano-sized hole through the rice cell's wall and membrane and inserting a nitrogen atom. So far, they've been able to change the colour of the grain, from purple to green.

Food Safety:
Scientists from the University of Wisconsin have successfully used single bacterial cells to make tiny bio-electronic circuits, which could in the future be used to detect bacteria, toxins and proteins [57].

Carbon Nanofibers and Carbon Nanoparticles:
The carbon nanofibers and carbon black nanoparticles are among the most commonly used nano size filling materials. Carbon nanofibers can effectively increase the tensile strength of composite nanofibers due to their high aspect ratio, while carbon black nanoparticles can improve abrasion resistance and toughness. Both have high chemical resistance and electric conductivity.

Nanotechnology in Textile Finishing:
Nanoscale emulsification, through which finishes can be applied to textile material in a more thorough, even and precise manner provide an unprecedented level of textile performance regarding stain-resistant, hydrophilic, anti-static, wrinkle resistant and shrink proof properties. The nanosize metal oxide and ceramic particles have a larger surface area and hence higher efficiency than larger size particles, are transparent, and do not blur the color and brightness of the textile substrates. Fabric treated with nanoparticles Ti_{02} and Mg_{O} replaces fabrics with active carbon, previously used as chemical and biological protective materials.

Drug Delivery Systems:
Nano-capsules, dendrimers (tiny bush-like spheres made of branched polymers), and "buckyballs" (soccer-ball-shaped structures made of 60 carbon atoms) for slow, sustained drug release systems, characteristics valuable for countries without adequate drug storage capabilities and distribution networks. Nanotechnology could also potentially reduce transportation costs and even required dosages by improving shelf-life, thermo-stability and resistance to changes in humidity of existing medications.

Food Processing and Storage:
Improved plastic film coatings for food packaging and storage may enable a wider and more efficient distribution of food products to remote areas in less industrialised countries; antimicrobial emulsions made with nano-materials for the decontamination of food equipment, packaging, or food and nanotech-based sensors to detect and identify contamination.

Air Pollution Remediation:
Nanotech-based innovations that destroy air pollutants with light, make catalytic converters more efficient, cheaper and better controlled; detect toxic materials and leaks, reduce fossil fuel emissions, and separate gases.

Construction:
Nano-molecular structures to make asphalt and concrete more resistant to water; materials to block ultraviolet and infrared radiation; materials for cheaper and durable housing, surfaces, coatings, glues, concrete, and heat and light exclusion; and self cleaning for windows, mirrors and toilets.

Health Monitoring:
Nano-devices are being developed to keep track of daily changes in physiological variables such as the levels of glucose, of carbon dioxide, and of cholesterol, without the need for drawing blood in a hospital setting [58]. For example, patients suffering from diabetes would know at any given time the concentration of sugar in their blood, similarly, patients with heart diseases would be able to monitor their cholesterol levels constantly.

The Potential Disadvantages of Nanotechnology:
The disadvantages of nanotechnology can be easily enumerated. Included in the list of disadvantages of this science and its development is the possible loss of jobs in the traditional farming and manufacturing industry. Atomic weapons can now be more accessible and made to be more powerful and more destructive. These can also become more accessible with nanotechnology. Since these particles are very small, problems can actually arise from the inhalation of these minute [59] particles, much like the problems a person gets from inhaling minute asbestos particles. Another disadvantage of nanotechnology in medicine is the use of nanomedicine in a malicious way. The proposed technology and applications can be used in a way which is not intended originally thus posing dangerous threat to human beings. Thus bringing in the issue of privacy and security, people can misuse nanotechnology for other purposes. Due the nanosize properties one can easily deceive people and take advantage. Presently, nanotechnology is very expensive and developing it can cost you a lot of money. It is also pretty difficult to manufacture, which is probably why products made with nanotechnology are more expensive. Practical problems can include everything from the need for mass produced forms of nanotechnology that may or may not be possible.

Ethical problems can include everything from the potential direction nanotechnology might take to the problems with the possible effects of the products created. Apart from the usual health effects one may experience from the nanoparticles, they are also very expensive. In the report presented by ETC group, Nanotech Rx, “the global health crisis doesn't stem from a lack of science innovation or medical technologies; the root problem is poverty and inequality [60]. New medical technologies are irrelevant for poor people if they aren't accessible or affordable.” One of the potential disadvantages of nanotechnology includes the potential for mass poisoning over a period of time. While nanoscience can produce all kinds of new and improved products, the particles that are created are so incredibly small that they may very well cause eventual health problems in the consumers that use them. Nanotechnology has raised the standard of living but at the same time, it has increased the pollution in water and air. The pollution caused by nanotechnology is known as Nano Pollution. Such kind of pollution is very dangerous for living organisms under water & on earth.

Nanoparticles can be used for drug delivery purposes, either as the drug itself or as the drug carrier. The product can be administered orally, applied onto the skin, or injected. The objective of drug delivery with nanoparticles is either to get more of the drug to the target cells or to reduce the harmful effects of the free drug on other organs, or both [61]. Nanoparticles used in this way have to circulate long distances evading the protection mechanisms of the body. To achieve this, nanoparticles are conceived to stick to cell membranes, get inside specific cells in the body or in tumours, and pass through cells. The surfaces of nanoparticles are sometimes also modified to avoid being recognized and eliminated by the immune system. It is true that nanotechnology has raised our standard of living but it has also led to an increase in the levels of pollution [62]. The pollution caused due to nanotechnology is known as Nano pollution and this can be very dangerous for living organisms. There are already reported incidents of disease development in individuals who have inhaled nanoparticles. There is no guarantee that the problems nanotech could solve wouldn’t just create new problems that don’t have a solution in the future that are even more problematic.

Nanotechnology Tools and Equipments:
In this section, we are exploring the Nanotechnology tools and equipments.

Atomic Force Microscope (Afm):
Atomic force microscopy (AFM) is also known as Scanning force microscopy (SFM) shown in figure 10. This device is used to visualizing, imaging, taking measures and for manipulating objects that are in nanometre scale. The resolution of such a device is said to be in the order of fractions of a nanometre.

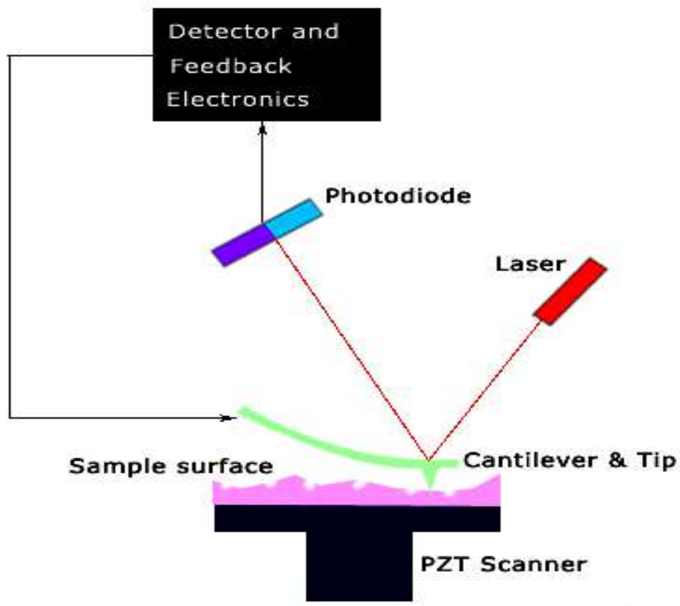

Fig 10:- The Atomic Force Microscope.

The earlier version of the AFM was called the Scanning Tunneling Microscope, developed in the early 1980's. The AFM was developed in the year 1986 by Binnig, Quate and Gerber at the IBM Research Zurich and earned them the Nobel Prize for Physics for the same year. The device consists of a mechanical probe that is used to sense the material that is placed on the surface. A highly accurate scanning procedure then takes place, through which the corresponding electronic signals are generated using piezoelectric materials. If the variations are deeper in scale, they can also be measured using conducting cantilevers.

Particle Size Analyzers:

Particle Size Analysis is a process used to determine and document the distribution of particle sizes in a solid or liquid sample. There are various types of particle size analyzers available, ranging from sieves to modern computerized light-scattering devices. The choice for a given application depends upon a range of factors including the target size range, character of the sample, the kind of analysis necessary, the analytical technique and sample throughput. The intended user must determine the data that is most important for their application when contemplating a large number of alternative particle sizing means and models.

Scanning Tunneling Microscope (STM):

Scanning Tunneling Microscope (STM) was developed in the year 1981 by Gerd Binnig and Heinrich Rohrer. An STM is used for imaging surfaces at the atomic level shown in figure 11. The lateral resolution of an STM lies around 0.1 nanometre and depth resolution lies around 0.01 nanometre. This measure is more than enough to manipulate a good image. With this resolution, individual atoms within materials are routinely imaged and manipulated. This method can be used in different modes like air, water, high vacuum, liquid and gas. It can also be used in very high and low temperatures. In an STM, when the tip of the device is brought near the material, a difference in voltage is applied between them. This difference causes the electrons to move through the empty space created between them. Such a method is called quantum tunneling. The method is very precise unless and until the parameters are maintained according to standards.

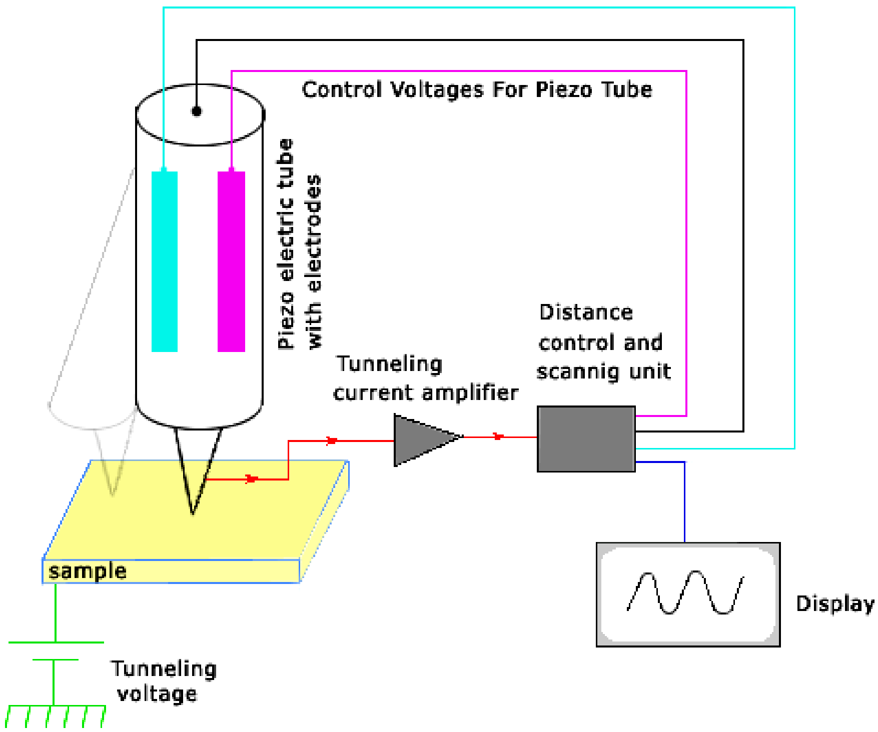

Fig 11:- The Scanning Tunneling Microscope.

Optical Tweezers:
Optical Tweezers use light to move objects as small as a single atom. Optical tweezer systems use a laser beam focused by a high-quality microscope objective to produce an "optical trap" which is capable of grabbing a small particle at its center using light-scattering and gradient forces. There are three primary types of optical tweezer systems. Microscope systems are built for researchers who want a basic optical tweezers solution with real-time, high-resolution capability, particle tracking, and a total software package.

Photoluminescence Mapper:
Photoluminescence is a spectroscopy process used to investigate electrical and optical qualities, such as emission wavelength, crystal structure, and defects in semiconductor materials. A photoluminescence mapper is a laser-based device used to produce maps of various parameters by determining optical luminescence emission from materials energized above their bandgap. A photoluminescence mapper can also be used for research activities like creating photoluminescence images of nanomaterials. These systems can also be used in conjunction with other analytical devices, like as part of a Raman spectrometer. A typical Photoluminescence Mapper can assess photoluminescence and Raman spectra from deep ultraviolet to the infrared part of the spectrum using a number of detectors.

Piezo Actuators:
Used for everything from semiconductor testing to biotech to aerospace, piezo actuators change electrical energy into linear motion with efficient speed, force, and practically unlimited resolution. These devices are quite distinctive in their ability to merge force, pace, and precision into a little package. Device makers typically place actuators inside larger framework to offer highly accurate guidance and amplified-motion capabilities.

Plasma Cleaning Systems:
Plasma cleaning is the common technique of getting rid of organic matter from an object’s surface by means of an ionized gas known as plasma. The technique frequently performed in a vacuum chamber using oxygen or argon gas. A plasma cleaning system is an environmentally-safe alternative to using harsh chemical solvents and an efficient way to remove small quantities of contaminants from a substrate. When a gas takes up electrical energy, it grows hotter, triggering the ions to vibrate faster and “scrub” a surface. In semiconductor production, plasma cleaning is often employed to prepare a wafer surface just before wire bonding.

Plasma Etching Systems:
Plasma etching systems are commonly used to 'coarsen' a surface on the micrometer scale. The process involves the exterior of a target material being affected by a reactive process gas, which induces both a chemical and physical reaction. In a plasma etching system, the plasma gas combines with the surface molecules of the target and takes the molecules up into the gas so they can be pumped away. The physical effect is brought on by high energy ions from the plasma, which scrub surface atoms away. In semiconductor production, plasma gasses react with the wafer to expunge an exposed pattern.

Pore Size Analyzers:
Pore size analyzers allow Scientists to establish the dimensions of surface micropores on materials like pharmaceuticals by determining their gas sorption abilities. Standard analyzers require placing a sample into a sealed chamber, where it is cleaned and exposed to gaseous adsorbate molecules. These devices then measure the degree to which the sample adsorbs the gas and determine pore size based on the sample' s surface area.

Profilometers:
A profilometer determines the surface profile of a sample on the nanometre scale. There are two kinds of profilometers stylus and optical. Stylus profilometers move a probe along the surface of a sample to determine its nanoscale topography. Stylus profilometry is extremely sensitive and supplies high-quality resolution. However, it is not highly responsive to soft surfaces, the probe can become tainted by the sample, and it can also be destructive to some very sensitive samples.

Raman Microscopes:
Raman spectroscopy is a spectroscopic technique used in condensed matter physics and chemistry to study vibrational, rotational, and other low-frequency modes in a system. It relies on inelastic scattering, or Raman scattering of monochromatic light, usually from a laser in the visible, near infrared, or near ultraviolet range. The laser light interacts with phonons or other excitations in the system, resulting in the energy of the laser photons being shifted up or down. The shift in energy gives information about the phonon modes in the system.

Raman Spectrometers:
Raman spectroscopy involves focusing a monochromatic (laser) light on a sample and detecting the light scattered by the sample, allowing for the identification and quantification of its component molecules. The simplicity and robustness of Raman Spectroscopy makes it suitable for a wide range of uses, ranging from investigating protein conformations to evaluating the temperature of a substance. When selecting a Raman spectrometer, the primary consideration should be the wavelength of the laser light that will be utilized to excite the sample. Since the technique is related to the vibrational framework of the sample, it is not dependent upon the excitation wavelength, and therefore, the selection of the excitation wavelength should be chosen for maximum efficiency.

Safety Cabinets, Glove Boxes and Atmosphere Control:
Many research and production operations involving nanomaterials must be conducted under isolation or in a strictly-governed environment. While this is often done to protect the nanomaterials from contamination, it can also be for safety reasons, as toxic materials, or inhalation hazards may be associated with the work being done. Fume hoods and cabinets offer a low-cost means for containing fumes and particulate matter. Re-circulating filtered fume cabinets defend against fumes and there is a limited range of chemicals for which a ducted fume cupboard cannot be installed. Filters purify the air before circulating it back to the room. Glove boxes allow materials to be manipulated without risk of exposure, possibly in a pressurized or vacuum environment.

Sample Preparation Equipment:
Preparing a sample properly can be the make-or-break factor in getting useful outcomes of a test. There are various means and kinds of equipment designed to make sample preparation easy and fast, including machines that cut, grind, clean and/or polish samples. For instance, a Triple Ion Beam Cutter can cut out cross-sections of hard, soft, highly-permeable, heat sensitive, fragile, and heterogeneous material for analysis via a scanning electron microscope, electron backscatter diffraction, atomic force microscope or any number of analytical techniques.

Scanning Electron Microscope:
Scanning Electron Microscopes (SEM) are microscopes that employ a targeted beam of electrons on a sample surface to produce an image. With the use of accessories, SEMs can be highly-versatile tools of modern science,

which can study the composition and fine details of both biological and physical samples. Nano mechanical testing systems can complement an SEM analysis by testing the mechanical properties on a nanoscale level.

Scanning Near-Field Optical Microscopes:
A scanning near-field optical microscope (SNOM) has the contrast capabilities of an optical microscope while also having significant spatial resolution abilities. The design of an SNOM can range considerably and one should be chosen based upon the demands of the particular project. In addition to optical data, an SNOM can also produce topographical or force data from the sample in the same way as an atomic force microscope. The two data sets can then be contrasted to establish the relationship between the physical structures and the optical contrast. This capability is much better than what is achievable under the diffraction limitations of focused light.

Scanning Probe Microscopes:
Scanning probe microscopes (SPMs) are used to create images of nanoscale surfaces and structures, possibly down to the atomic scale. These devices use a probe tip attached to the end of a cantilever to scan back and forth across exterior of a sample to produce an image. In addition to visualizing structures, some kinds of SPMs can be used to move individual atoms. There are many kinds of SPMs. Atomic force microscopes (AFMs) gauge the electrostatic forces between the probe tip and the sample. Magnetic force microscopes (MFMs) evaluate magnetic forces between the two objects and scanning tunneling microscopes (STMs) gauge the flow of electrical current.

Scientific Cameras:
Scientific cameras capture still or moving images in the visible or non-visible parts of the electromagnetic spectrum, as ultraviolet and infrared light. As imaging technologies progress, the kinds of cameras and their abilities are constantly advancing to satisfy the needs of countless applications. Used in the biotech, semiconductor, electronics, and manufacturing sectors, scientific cameras offer a degree of investigation that is essential for achieving research or quality control objectives.

Scratch Testers:
A scratch tester is a mechanical device commonly used to evaluate the scratch resistance of a surface, which includes coatings, metals, ceramics, and polymers. Typically, a test panel is clamped down and slowly moved while a stylus scratches the sample surface. Based on test procedures, set or variable loads can be applied to achieve various results, from trace scratches to destruction of the sample. Sliding rate, direction, stylus shape and stylus material can also be varied to provide different results.

Separation Membranes:
Membrane separation is a technique used to selectively divide materials through the use of tiny pores and/or gaps in a layer of material. Membrane separations are categorized by pore size and by the separation driving pressure, and categories include Microfiltration, Ultra filtration, Ion-Exchange and Reverse Osmosis (RO). Membranes are often engineered with certain features or are included in devices to achieve particular results. For instance, a selectively degradable nano porous membrane allows for tissue engineering and direct connections between co-cultured cells after they attain confluence, while the negatively-charged membrane is made to considerably decrease binding and loss, compared to standard materials.

Spectrofluorometers:
Spectrofluorometers gauge the degree of analyze in a sample by sensing its fluorescence signature, which is based on particular excitation and emission wavelengths of light. To test a sample, a specific wavelength of light is sent through the sample, which is held inside a cuvette, exciting analyzes in the sample. After excitation, analyze emits light at a wavelength longer than the excitation wavelength. A detector then gauges the emitted light, shows the fluorescence value and determines the fluorescence signature of the analyze. The amount of analyze in the sample can then be determined. A spectrofluorometer is often used in bio-fuels analysis, biotechnology, quality control, medical analysis, materials science, and academia.

Spectrometers:
A spectrometer identifies, evaluates, and analyzes various wavelengths of light. A spectrometer takes in light through a narrow entrance slit. In many spectrometers, the light is then directed onto a grating by a concave mirror. The grating then spreads out the spectral elements of the light at somewhat varying angles, which is then concentrated by a second concave mirror and imaged onto a detector. As soon as the light hits the detector, it is then

modified into electrons which are digitized and sent to a computer, which plots the spectral information as a function of wavelength over the given spectral range. This information can then be used for many spectroscopic applications.

Spectrophotometers:
The Spectrophotometry is a technique used to assess the amount of light a chemical substance absorbs by measuring the power of a light beam after it goes through a sample solution. The technique is based on the notion that each substance absorbs or emits light over a particular wavelength range. Measuring the intensity of a light beam can also be used to evaluate the quantity of a compound in a sample. There are two main classes of spectrophotometers: single and double beam. A single beam spectrophotometer determines the absolute intensity of the light beam. A double beam spectrophotometer gauges the ratio of the light intensity on two different light paths. The Spectrophotometry is one of the best techniques of quantitative investigation in many fields, including chemistry, physics, chemical engineering, and food science.

Spectroscopic Ellipsometers:
Spectroscopic ellipsometry is a sensitive, non-destructive and non-intrusive process commonly used to determine thin-film thickness and optical constants of modern semiconductors. Spectroscopic ellipsometers reliably and accurately determine the real and the imaginary parts of the optical dielectric constant as a function of wavelength for semiconductors, metals and other thin-film materials. Ellipsometers can also determine depth-profiles with nearly atomic resolution; the composition for any sample layers; the microroughness of the sample exterior; and the near-surface temperature of samples. Spectroscopic ellipsometry is great for a variety of thin film applications from fields like biotechnology, semiconductors, solar and surface chemistry.

Spectroscopy Accessories:
A spectrometer analyzes light and various accessories can expand this device's capabilities for a variety of scientific applications. Hydraulic presses are used to crush pellets into fine powers, which can then be tested using X-ray fluorescence (XRF), Fourier transform infrared spectroscopy (FTIR) or any number of spectroscopic techniques. ATR (attenuated total reflection) accessories are designed for spectroscopic analysis of various materials in specific ranges of infrared light.

Sputtering Systems:
A method at the core of today's semiconductor and optical device production, sputtering is used to put down extremely thin films of a material onto a surface, typically referred to as a substrate. Spluttering systems start with the substrate and coating source material being placed into a vacuum chamber that is then filled with an inert gas. The source material is then given a negative charge and free electrons from the negatively-charged source material flow into the inert gas, turning the gas atoms into positively-charged ions. These ions are drawn to the negatively-charged source material at high speed and this causes atomic-sized particles from the source material to "sputter off" as a result of high-speed collisions.

Streak Cameras:
A streak camera is a scientific device used for gauging the variance in intensity of a pulse of light over time. To perform a test, the light pulse is quickly deflected across a detector. The spatial distribution caused by the moving spot, known as the streak image, then shows the temporal progression of the light's power, as each point in time is mapped to a spatial position. The resulting streak image is a linear with varying light intensity.

Surface Analyzers:
As the name indicates, surface area analyzers obtain the surface area, or average pore size, of a solid sample by testing their gas sorption abilities. After the samples have been put into an enclosed chamber and cleaned, adsorbate molecules are pumped into the chamber. The amount of gas adsorption by the sample helps to show the surface area. Pressures inside the chamber can hit 1000 torr and temperatures often surpass 425 °C. Gases frequently used in surface area analyzers are argon, carbon dioxide, helium, nitrogen, and krypton. Some devices integrate a preparation stage and temperature conductivity monitors to guarantee even heating across the sample. The best devices are capable of detecting leaks, evacuating gas and performing the analysis simultaneously.

TEM Sample Holders and Supplies:
Transmission electron microscopy (TEM) is a process that images nanoscale features of a specimen using a beam of electrons. An image is produced when electrons interact with the sample as they pass through it. The image is then amplified and focused onto an imaging device or medium, such as a photoelectric sensor or layer of film.

Thermal Analysis Equipment:
Thermal analyses are used to track the various properties of materials as they change with temperature. These tests can be done with a wide range of methods, including Thermo gravimetric analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Colorimetry (DSC), Dilatometry and Thermomechanical Analysis (TMA), Dynamic Mechanical Analysis (DMA) and Dynamic Mechanical Thermal Analysis (DMTA). Most modern thermal analysis equipment can perform multiple different methods, often at the same time.

Thermal Desorption Equipment:
Thermal desorption is a technique that removes contaminants from a heterogeneous mixture of solids by using heat to raise contaminant volatility. Thermal desorption equipment can be either fixed or mobile and are composed of two common categories: Primary-Fired, and Indirect-Fired. Figuring out the most effective model for a given application calls for an understanding of the material to be processed and any relevant regulatory demands.

Thin Film and Coating Thickness Measurement Tools:
The coatings and thin films are applied to the surface of materials to alter their properties. Being able to measure the thickness and uniformity of these thin films is important as variations can impact the properties and performance of the final device.

Thin-Film Deposition Systems:
Thin-film deposition is any technique for depositing a thin film of material onto a substrate. Most deposition techniques allow layer thickness to be controlled within a few tens of nanometers. On the other hand, some techniques allow single layers of atoms to be deposited at a time.

Transmission Electron Microscopes:
A transmission electron microscope (TEM) functions similar to a standard microscope, but uses electrons rather than visible light. Because a TEM uses the much smaller wavelength of electrons, it can resolve details just a few angstroms in size, which is 1000 times smaller than what [64] can be seen with a standard light microscope. To examine a sample, the microscope sends its electron beam through the specimen, where some electrons are scattered from the beam.

Tribometers, Friction and Wear Testers:
The Tribometers offer comprehensive methods for investigating various materials with respect to friction, wear, load, firmness, and lubrication. Types of tribometers include four-ball testers, which perform Wear Preventive (WP) and Extreme Pressure (EP) tests, Bio Tribometers, which replicate biological environments, High-temperature Tribometers, Low-temperature Tribometers, Vacuum Tribometers, Micro Tribometers, Nano Tribometers and Scratch Test Instruments.

Ultrasonic Processing Equipment:
The Ultrasonic Processing Equipment sends high-frequency sound waves into a liquid to perform any of a number of tasks. The vacillating waves of low and high pressure created by this equipment make tiny bubbles that collapse violently via a process call cavitation. This can be used for deagglomeration of nanometre-sized materials, cleaning, and mixing and cell disintegration.

Vibration Isolation Systems:
Used with high-precision equipment like scanning electron microscopes, vibration isolation systems are used to keep samples stationary so they can be examined with a high degree of accuracy and little noise. These systems typically use mechanical devices or air pressure to dampen vibrations.

Viscometry & Rheometry:
The Viscosity is a measure of how “thick” a liquid or gas is; i.e. its internal resistance to flow. Viscosity can also be thought of as a measure of internal friction. It can be determined with a glass viscometer, which uses a capillary tube

to determine flow. Rheology is a [63] far more intricate study of the flow of matter, including liquids, soft solids, gels, pastes and even hard solids like glacial ice, which exhibits a degree of flow. Rheology is used on complex materials that cannot be described by a single value of viscosity. Rather their viscosity transforms with shifting conditions.

Wafer Bonders:
Used in the production of semiconductors, wafer bonders are devices that allow for a mechanically-stable and sealed packaging of micro electro mechanical systems (MEMS), nano electro mechanical systems (NEMS) and optoelectronics. Normally, a temporary bond is made with a bonding agent or a permanent bond of oxide film surfaces is made by a self-bonding process. Temporarily bonds are separated after the completion of a vertical electrical connection through a silicon wafer, a sequence known as TSV. Wafer bonding has become a fundamental core capacity for any high-volume MEMS production facility that makes anything from accelerometers to silicon sensors for automotive, aerospace and consumer devices.

X-Ray Cameras:
The use of film and analog X-ray imaging has been replaced by digital technology in most areas of science and research. The result has been greater operational efficiency, faster work flow, better-archiving infrastructure, easier sharing of outcomes, better image processing abilities, lower X-ray dose and real-time availability of images.

X-Ray Detectors:
The X-ray detectors use scintillators and arrays of silicon photodiodes or semiconductors to detect the X-ray region of the electromagnetic spectrum. Scintillators change x-rays into visible light and electrons, which are read by a thin layer of glass and silicon, a device known as a thin-film transistor (TFT) array. Scintillator-based indirect flat panel detectors (FPDs) are in common in medical, veterinary, [65] and industrial applications. Semiconductor detectors directly convert x-ray photons into an electrical charge to create a digital picture.

X-Ray Diffractometers:
The X-ray diffractometers are often used for phase identification of a crystalline test sample. These devices provide a powerful and quick process for identification of an unidentified mineral, and often, it supplies an unambiguous identification through the identification of cell unit sizes. The technology is based on the production of X-rays in an X-ray tube. X-rays are focused on the sample, and the diffracted rays are gathered.

X-Ray Fluorescence Analyzers:
The X-Ray fluorescence (XRF) analyzers can be used determine the chemical makeup of a material by measuring the X-rays released from a sample when it is energized by a principal X-ray source. Every element contained within a sample generates a distinct group of fluorescent X-rays, essentially "a fingerprint" of each element. By determining the strength and distinctive energy of the released X-rays, an X-ray fluorescence analyzer can offer qualitative and quantitative information on the thickness and makeup of the material being subjected to testing.

X-Ray Photoelectron Spectrometers:
The X-ray photoelectron spectroscopy is a common surface analysis method because it can be used on a wide variety of materials and supplies valuable quantitative and chemical data. X-ray photoelectron spectrometers excite a sample with x-rays to produce photoelectrons. A detector is then be used to gauge the energy of the released photoelectrons, allowing for the qualitative and quantitative identification of a sample and its chemical state. The data X-ray photoelectron spectrometers supply is critical for many commercial and research applications where surface or thin film composition plays an integral role, including in nanomaterials research, photovoltaics research, corrosion investigation, display technology and thin-film coatings used for various applications.

Zeta Potential Analyzers:
The zeta potential of a sample is frequently used to convey the stability of dispersion with a higher zeta potential indicating a more stable the dispersion. Zeta potential analyzers use one of two methods to determine zeta potential. First, an analyzer may apply an electric field and measuring the resulting velocity of charged particles. Second, an analyzer might use ultrasonic waves to create motion and then assess the charge of moving particles. These devices are used in a range of applications, including in pharmaceutical research, mineral processing, water treatment, and electronics production.

Optical Non-Contact Profilers:
The Optical non-contact profilers assess nanoscale height differences on a surface with a high degree of precision. Based on the known wavelengths of light, optical non-contact profilers can measure a sample in three dimensions. Optical profiling allows for the measurement of a surface's finish, roughness, and shape, as long as enough light is reflected back into the profiler's objective from the sample. Some optical non-contact profilers may be limited with regards to measuring very high slopes, where the light is reflected away from the objective, except if the slope has sufficient texture to mirror light back to the objective. These devices are used [65] in many instances where micro-measurement of surface variations is required. Industries like optics and data storage use highly refined surfaces that are assessed with interference Profilometers.

Optical Characterization Systems:
The Optical Characterization Systems, such as optical coordinate measurement machines (CMM) or refractive index detectors, use optical tactics to examine of solid-state and biological samples at the nanoscale. To discover the physical geometrical qualities of an object, optical CMMs use arm-free scanning systems and optical triangulation processes, which allows for complete freedom of movement around the object being scanned.

Nanoparticle Production Systems:
Nanoparticle production systems generate nanoscale particles in a precisely-defined, limited range of sizes for a range of uses, including the production of formulated coatings and other composite materials. Specific production and reaction factors are essential to produce the desired size-dependent particle features. Particle proportions, chemical makeup, crystallinity, and form can be chosen by adjusting temperature, pH, chemical composition, surface alterations, and process factors [66]. Two standard nanoparticles production systems are used: 'top-down' and 'bottom-up'. 'Top-down' refers to the physical crushing of source material using a milling system. 'Bottom-up' strategies build particles via chemical operations. Choosing a method should be determined by the chemical makeup and the features chosen for the nanoparticles.

Nanoparticle Characterization Systems:
Nanoparticle characterization is a process used to characterize and control nanoparticles for material synthesis and other applications. Because these particles are too small to investigate using visible light, nanoparticles characterization systems use electro-phoretic light scattering (ELS), dynamic light scattering (DLS), and static light scattering (SLS) to discover particle size, occurrence of aggregates in a sample, particle count, molecular mass and zeta potential, an essential indication of the integrity of colloidal dispersions. Most conventional systems can identify particle sizes ranging from 0.3 nanometers to 10 micrometers.

Micro Hardness Testers:
The ASTM E-384, micro hardness testing specifies an allowable range of loads for testing with a diamond indenter. The resulting indentation is then recorded and converted to a hardness value. Typically loads are very light, ranging from a few grams to one or several kilograms. Since the test indentation is very small, micro hardness testing is useful for a variety of applications such as testing very thin materials like foils or measuring individual micro-structures.

Micro Fluidic Devices:
The Micro fluidics is a new technology platform that deals with the behavior, precise control, and manipulation of fluids that are geometrically constrained to a small, typically sub-millimeter, and scale. Micro fluidic and nano fluidic systems analyze by controlling the flow of liquids or gases through a series of tiny channels and valves, thereby sorting them, much as a computer circuit sorts data through wires and logic gates. Micro fluidic channels, often etched into silicon, can be less than 100 nm wide. This allows them to handle biological materials such as DNA, proteins or cells in minute quantities usually nano-liters or pico-liters.

Moisture Analyzers:
Moisture analysis covers a variety of methods for measuring moisture content in both high level and trace amounts in solids, liquids, or gases.

Nano 3D Printing:
Nano 3D printing is used to produce structures through a range of methods including additive manufacturing, at the micron and submicron level out of a range of materials.

Nanoimprint Lithography Equipment:

Nanoimprint Lithography or NIL is a process used to fabricate nanoscale patterns typically used in the areas of electronics, optics, photonics, or biology. It creates patterns by mechanically deforming an imprint resist that is typically made from a monomer or polymer and cured using UV light. The Nanoimprint lithography process is characterized by low cost, high throughput and high resolution and is a much simpler process than its rival optical lithography.

Nanolithography Systems:

Nanolithography refers to the fabrication of nanometer-scale structures, meaning patterns with at least one lateral dimension between the size of an individual atom and approximately 100 nm. Nanolithography is used during the fabrication of leading-edge semiconductor integrated circuits or nano electromechanical systems (NEMS).

Micromechanical Testing:

The Micromechanical methods include compression, tension, and bending tests, shear testing, adhesion testing fatigue testing and fracture toughness. Thin film testing methods such as bulge testing and thermal straining are also used. This range of combined micromechanical tests is used to measure the mechanical properties of materials directly at the nano scale. In particular, micromechanical testing focuses on the influence of surface microstructure on mechanical properties, as opposed to relying on conventional geometry-independent measurements like the elastic modulus.

FT-IR and FT-NIR Spectrometers:

FT-IR (infrared) and FT-NIR (near infrared) spectroscopy deal with specific regions of the electromagnetic spectrum and unlike other techniques like Raman, these instruments can measure their entire range of wavelengths simultaneously. The techniques rely on the fact that molecules absorb specific frequencies that are characteristic to their structure. These frequencies are dictated by such things as the shape of the molecular potential energy surfaces, the masses of the atoms, and the associated vibronic coupling and can thus be used to characterize materials and systems.

Inductively Coupled Plasma:

The Inductively coupled plasma (ICP) is a type of plasma source in which the energy is supplied by electric currents which are produced by electromagnetic induction, that is, by time-varying magnetic fields.

Energy Dispersive X-Ray Spectroscopy:

The Energy Dispersive X-Ray Spectroscopy (EDS) is a microanalysis method used in addition to scanning electron microscopy (SEM). EDS provides chemical information by detecting x-rays released from a sample being bombarded by an electron beam from a standard SEM. When the sample is inundated by the SEM's electron beam, electrons are thrown from the atoms on sample's exterior. The subsequent electron openings in these atoms are then stocked by electrons from a higher state, and an x-ray is released to stabilize the energy difference between the two states. EDS is a cheap, versatile way to acquire a quick compositional analysis.

Electron Backscattered Diffraction:

The Electron Backscattered Diffraction (EBSD) Systems can determine quantitative micro structural data on metals, minerals, semiconductors, ceramics, and most other inorganic crystalline materials. Microstructure has an impact on a material's attributes and behavior. The describing microstructure is critical to understanding a material and its functionality. In commercial operations, material processing significantly affects microstructure, which impacts the properties of the material. Therefore, microstructure analysis is becoming increasingly critical in a lot of different industries and study areas, including metals research materials engineering, renewable energy study, and the advance of microelectronics.

Dynamic Light Scattering Instruments:

The Dynamic Light Scattering Instruments (DLS) is often used to analyze nanoparticles. In a DLS analyzer, a sample is struck by a laser beam and the variations of the light scattered by the sample are detected at a recognized scattering angle. Basic analyzers in DLS instruments evaluate at a fixed angle to determine the average particle size in a particular size range. More complex instruments can determine the complete particle size distribution.

Cryogenic Probe Stations:
As semiconductor devices become more compact and state-of-the-art materials are increasingly used to make them, the qualities of these devices are becoming more and more exotic. Researchers have found that most of the essential semiconductor studies done today must be performed at cryogenic temperatures, where low thermodynamic energies allow for more precise testing. Cryogenic probe stations supply [65] a high-vacuum cryogenic environment for practical, reliable testing of electro-optical, direct current, radio frequency or microwave attributes of semiconductors, early-stage devices, circuits, and materials, including unique photovoltaic materials.

Coating and Deposition Equipment:
The Coating and deposition equipment is designed to create thin layers of a material via chemical vapor deposition, physical vapor deposition, electrochemical techniques, spraying or roll-to-roll processes. In chemical vapor deposition, a thin wafer is subjected to a number of volatile vapor precursors, which react with and/or decompose on a substrate surface to create the desired deposit layer. With physical vapor deposition [63], material transforms from a condensed phase to a vapor phase to a thin-film condensed phase.

CCD Cameras & Spectrometers:
The CCD or Charge Coupled Devices typically have a sensor integrated into them. The sensor may detect light, ultraviolet light, x-rays etc, and converts these into digital information, to create digital images. As such CCD cameras find many applications in materials science, medicine, astronomy etc to capture digital images.

Carrier Concentration:
The carrier concentration is an important property of every semiconductor and this is directly related to do pant concentration. The concentration and homogenous distribution of the do pant introduced to an intrinsic semiconductor indirectly affects many of its electrical properties. Being able to measure the distribution and concentration carriers is an extremely important operation for the manufacturers of semiconductors.

Biological Atomic Force Microscopes:
Atomic force microscopes (AFM) are one of the most powerful tools for determining surface topography at sub nanometer resolution. A biomedical Atomic force microscope (bio-AFM) paves the way for a multitude of applications in Soft Matter and Life Science research.

Atomic Layer Deposition Systems:
Atomic layer deposition (ALD) is a thin film deposition technique that is based on the sequential use of a gas phase chemical process. The majority of ALD reactions use two chemicals referred to as precursors. ALD provides a unique method for depositing ultrathin films on surfaces.

Atomic Force Microscopes:
Atomic force microscopes (AFM) are one of the most powerful tools for determining surface topography at sub nanometer resolution. The technique involves imaging a sample through the use of a probe, or tip, with a radius of 20 nm. The tip is held several nanometers above the surface using a feedback mechanism that measures surface tip interactions on the scale of nano Newton's. Variations in tip height are recorded while the tip is scanned repeatedly across the sample, producing a topographic image of the surface.

Atomic Emission Spectrometers:
In atomic emission spectroscopy, a sample is exposed to an electrical arc, a flame, or plasma to generate excited state atoms that are capable of emitting light. The unique emission spectrum of a sample can then be harnessed for a qualitative and quantitative identification of elements in that sample. The spectra of specimens with many elements can be packed tightly together and the spectral parting of adjacent atomic transitions demands a high-resolution spectrometer.

Atom Probes:
The Atom probe is a microscope used in material science. The atom probe is closely related to the method of Field Ion Microscopy. Atom probes are unlike conventional optical or electron microscopes, in that the magnification effect comes from the magnification provided by a highly curved electric field, rather than by the manipulation of radiation paths.

AFM Tips, Probes, Cantilevers:
An atomic drive microscope (AFM) uses a tiny, sharp probe to assess properties of a surface, like topography, friction, magnetism, and electrical conductivity. An AFM is capable of making these measurements by determining the pressure between a probe and the sample. Typically, the probe has a pyramid tip that is 3 to 6 micrometers tall. To resolve an image, AFMs can typically assess the vertical and lateral deflections of a cantilever using an optical lever [65], which bounces a laser beam off the cantilever.

AFM Raman Systems:
Atomic force microscopy and Raman spectroscopy are techniques used to obtain data about the surface properties of a sample.

Optogenetics:
The brain activity mapping is tightly linked to optogenetics the use of light to control well-defined events within targeted elements of intact biological systems. Optogenetic tools are themselves nanoscale devices that can be engineered for new classes of brain activity mapping function, building on molecular structure-function relationships.

Conclusion:-
In a time frame of approximately half a century, nanotechnology has become the foundation for remarkable industrial applications and exponential growth Nanotechnology literally means any technology on a nanoscale that has applications in the real world. Nanotechnology encompasses the production and application of physical, chemical, and biological systems at scales ranging from individual atoms or molecules to submicron dimensions, as well as the integration of the resulting nano structures into larger systems. Nanotechnology is likely to have a profound impact on our economy and society in the early 21st century, comparable to that of semiconductor technology, information technology, or cellular and molecular biology. The term "nanotechnology" has evolved over the years via terminology drift to mean "anything smaller than micro technology," such as nano powders, and other things that are nanoscale in size, but not referring to mechanisms that have been purposefully built from nanoscale components. In this survey paper, we review the background and state-of-the-art of Nanotechnology, categorizing of Nanomaterials, controversy in Nanotechnology and potential disadvantages of Nanotechnology. The definition implies using the same principles and tools to establish a unifying platform for science and engineering at the nanoscale, and employing the atomic and molecular interactions to develop efficient manufacturing methods. Finally, we are widely investigated the Nanotechnology tools and equipments. These surveys aim to provide an extensive overview Nanotechnology in current scenario.

Acknowledgements:
The author would like to thank the reviewers anonymous for their constructive comments and that helped whit their revision to improve the resulting quality of this paper. I would like to express my gratitude towards my family, my educator, and colleges for their co-operation and help me in completing this paper.

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