

Nanotechnology Innovations & Business Opportunities : A Review

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ABSTRACT

Nanotechnology deals with understanding and control of matter at dimensions of roughly one to one hundred nanometers. It involves the creation and use of structures, devices and systems that have novel properties and functions because of their small size, and the ability to control or manipulate matter on an atomic scale. Being anticipated as one of the major breakthrough technology of 21st century, nanotechnology has solutions for all the problems of mankind and fulfills all necessary desires for human prosperity. The applications of nanotechnology in different identified areas provide lots of business opportunities. It includes Food, Medicine, Cleaner water, Better quality air, Electronics, Fuel Cells, Solar Cells, Batteries, Space Travels, Chemical sensors, Sporting goods, Fabrics, Cleaning products, Energy, Environment, Health, and Life span increase. The paper covers the applications, benefits and uses of nanotechnology innovations in different industries, possible business opportunities for new nanotechnology based products and services due to challenges for human prosperity on earth, the impact of nanotechnology on business, and the global strategy on nanotechnology business with an expected time scale and future possibilities of nanotechnology innovations and the magic (like science fictions) going to happen in human life. The discussion also emphasize how nanotechnology is going to be a disruptive innovation by solving all problems in the society like food, energy, drinking water, health and environment and rendering human life limitless.

Keywords : Nanotechnology, business opportunities of nanotech products, Strategy to market nanotech products.

I. Introduction

Nanotechnology is expected as major breakthrough technology of this century and is defined according to the National Nanotechnology Initiative (NNI), as the “understanding and control of matter at dimensions of roughly one to one hundred nanometers, where unique phenomena enable novel applications,” (Jo Anne Shatkin, 2008). The U.S. Environmental Protection Agency (EPA) (Oberdörster et.al., 2005) defines nanotechnology as “research and technology development at the atomic, molecular, or macromolecular levels using a length scale of approximately one to one hundred nanometers in any dimension; the creation and use of structures, devices and systems that have novel properties and functions because of their small size; and the ability to control or manipulate matter on an atomic scale. Scientists have been studying and working with nanoparticles for centuries. But the ability to see nano-sized materials using high powered microscope has opened up a world of possibilities in variety of industries and scientific endeavors. Since nanotechnology is a set of techniques used to manipulate the properties of matter at microscopic scale, it can support many applications in the society especially to solve problems of living being. Nanotechnology is viewed as a group of technologies over time and is expected to support innovative new product developments. Lux Research, Inc., the New York-based nanotechnology research and advocacy firm, predicts that by 2015 products that incorporate nanotechnology will constitute 15 percent of global manufacturing output and will total \$3 trillion. Products of nanotechnology are diverse and growing exponentially due to high priority research investments by many countries,. According to the NNI, nanoparticles and nanoscale materials are used in many industries, including agriculture, food, energy, electronics, pharmaceuticals, chemicals, and biomedical, among others. Many areas of industries are producing the greater revenue for nanoparticles are chemical-mechanical polishing, solar panel coatings, magnetic recording tapes, sunscreens, automotive catalyst supports, biolabeling, electroconductive coatings and optical fibers. Many nano-enabled products are available in the market today, which include paints, cosmetics, stain-resistant clothing, electronics, surface coatings, sporting goods etc., among other applications (Frank et.al., 2007). According to RNCOS, the global nanotechnology market has been witnessing a growth at a compound annual growth rate (CAGR) of around 19% during 2011-2014 (www.uneca.org). The future prospective growth will be largely driven by massive investment in nanotechnology R&D and commercialization by both governments and corporate worldwide. In coming years, it is expected that nanotechnology based products and services will have a huge impact on most of the industrial sectors and will

enter the consumer market in large quantities. Some researchers believe nanotechnology can be used to significantly extend the human lifespan or produce replicator- like devices that can create almost anything from simple raw materials. Others see nanotechnology only as a tool to help us to do what we do now, but faster or better. The third major area of debate concerns the timeframe of nanotechnology- related advances. Will nanotechnology has significant impact on our day to day lives in a decade or two, or will many of these promised advances take considerably longer to become realities (Aithal and Shubhrajyotsna, 2015'a"). Based on the ability, advantages and applications of nanotechnology in solving problems in almost all areas of the society, it can be considered as an ideal technology (Aithal and Shubhrajyotsna, 2015'b"). Only time will tell how nanotechnology will affect our lives. The applications of nanotechnology identified in different areas provides lots of business opportunities which includes Medicine, Electronics, Food, Fuel Cells, Solar Cells, Batteries, Space Travels, Fuel, Better air quality, Cleaner water, Chemical sensors, Sporting goods, Consumer goods, cosmetics, Fabrics, Cleaning products, automobiles, Energy, Environment, Health, Life span increase etc. These business opportunities may create new business model with a challenge of educating people in usage of these innovative products & services safely to harness their advantages and benefits.

The paper covers the applications, benefits and uses of nanotechnology innovations in different industries, possible business opportunities for new nanotechnology based products and services due to challenges for human prosperity on earth, the impact of nanotechnology on business, and the global strategy on nanotechnology business with an expected time scale and future possibilities of nanotechnology innovations and the magic (like science fictions) going to happen in human life. The paper also covers how nanotechnology is a disruptive innovation going to solve all present major problems due to increased population in the society like food, energy, drinking water, health and environment.

II. Challenges for Human Prosperity

The emerging nanotechnology is expected to solve both basic needs and comfort needs of human beings. The basic needs of human being are food, drinking water, energy, cloth, shelter, health and environment and the comfort needs are realizing the automation in every field, space travel and expanded life-span and so on. Nanotechnology is sometimes referred to as a general-purpose technology. That's because in its advanced form it will have significant impact on almost all industries and all areas of society. It will offer better built,

longer lasting, cleaner, safer, and smarter products for the home, for communications, for medicine, for transportation, for agriculture, and for industry in general (Wonglimpiyarat, 2005).

(1) Food : One of the basic necessities of human being in this society is nutritious food. Due to various reasons, people of major part of the world are struggling to get nutritious food for their hungry. Nanotechnology innovation in agriculture is expected to solve the problems in food sector and maximizes productivity in agriculture. There is an ever-increasing demand for food and adequate nutrition, while world grain harvest has fallen short for the last few years. Biodiversity is being destroyed worldwide and half of our world's forests and a quarter of our coral reefs are gone during last century. The world population is currently at 6.4 billion and is estimated to swell to 8.9 billion by the year 2050. It is anticipated that 98% of this growth will be in poorer countries. It is also predicted that there will be 5 billion city dwellers by 2030 which will place heavy demands on the growth and distribution of food. Nanotechnology will provide solutions through precision farming using nanosensors, nano-pesticides, and inexpensive decentralized water purification. A more advanced nanotechnology solution will be plant gene therapy; creating pest resistant, high yield crops that require less water (Gruère, 2012).

(2) Drinking Water : Another basic necessities of human being in this society is clean drinking water. People of many countries are severely suffering due to non-availability of pure drinking water. Nanotechnology has potential to provide efficient, cost effective and environmentally sustainable solutions for supplying portable water for human use and clean water for agricultural and industrial uses. Nanotechnology innovations in low cost water purification are expected to solve drinking water problem of the world. Agriculture currently uses 70% of the world's water supply. To feed 2 billion more by the year 2030 there will be a 60% increase in demand on the water supply. Considering the current rates of consumption, population and development, some two-thirds of the world population will be affected by droughts by the year 2050 which will increase the demand for fresh water. Nanotechnology will provide solution for this challenge through inexpensive decentralized water purification, detection on the molecular level of contaminants, and greatly improved filtration systems. This helps conversion of sea water into drinking water at very low cost (Brame, 2011).

(3) Cleaner Breathing Air : Clean air for living beings breathing with required amount of oxygen content is very essential for sustained living on this earth. Based on continued and

enhanced pollution and added green gases, the atmosphere gets polluted and contaminated. This created serious problems in human health conditions. Enhanced transportation vehicles and industrialization are partly responsible to this atmospheric degradation. Nanotechnology based new membranes use electrostatic forces to sort molecules by size and can also separate some gases, potentially providing an economical way to capture and prevent the atmospheric release of carbon dioxide from power plants & automobiles. By means of using nanotech based air cleaners at suitable places, the essential percentage of oxygen in the atmosphere can be maintained.

(4) Renewable Energy : Energy is the most important basic resource after food and water for human prosperity. Demand for energy on earth is forecasted as increasing 50% by the year 2025 with most of these being fossil fuels. Currently over 1.6 billion humans have no access to electricity and 2.4 billion rely on plant material, vegetation, or agricultural waste as an energy and heating source. It is estimated that our fossil fuel consumption is escalating and could become double by the year 2025. Meanwhile, Earth's glaciers are receding, the CO₂ concentrations in the atmosphere have nearly doubled, and world temperatures, recorded since 1861, were the hottest in three of the past five years. 1998 was the warmest of record, 2001 came in the second warmest and 2004 was the fourth warmest (Knell, 2011). Nanotechnology innovations in renewable energy solves entire energy requirement of human beings for their basic needs and for the comfortable life. Balancing humankind's need for energy with the environmental cost to our planet is a major challenge. Nanotechnology based energy solutions through more efficient lighting, fuel cells, hydrogen storage, solar cells, locally distributed power generation, and decentralized generation and storage by reinventing the power grid are expected to create more potential business opportunities.

(5) Clothing : The fourth basic necessity of human being is cloth. The nature of cloth required to protect their body from the surrounding environment depends on the geographical location on the earth surface. Nanotechnology research opened avenue to make composite fabric with nano-sized particles or fibers allows improvement of fabric properties without a significant increase in weight, thickness, or stiffness as compared to previously-used techniques. It supports creating fabrics that do not wrinkle, stain, or allow the growth of bacteria. Many products that available in markets like anti-microbial socks; underwear and sporting apparel; wind and water proof jackets; wrinkle and stain resistant suits; casual wear; and swimsuits that protect against UVA and UVB rays are all products that are treated with nano-coatings or use nanotechnology in the manufacturing process. The advantages of

nanotech fabrics are water and stain resistant, insulates against heat or chill, dirt rinses off in rain, reduces odours and bad smell (Kaounides, 2007).

(6) Shelter : Another basic necessity of civilised human being is protective shelter. Nanotechnology offers interesting new opportunities in the construction sector through the development of energy efficient, ultra high strength, extra durable, extremely lightweight construction materials. Nano-modification of cement is an emerging field. Synthesis and assembly of materials in the nano-meter scale offers the possibility for the development of new cement additives such as novel super-plasticisers and nano particles. It is now possible to manipulate the fundamental structure of cement phases to control concrete properties, performance and durability. Nano-modification also provides crucial information for predicting the service life of concrete more accurately and insights on improving it further. Preceded by the IT and software revolution, nanotechnology and science are expected to usher a new paradigm shift in all spheres of technology including infrastructure and construction (Bartos, 2004).

(7) Human Health : The degraded environment and its consequence on human health is another challenge for human prosperity. In the previous centuries, men and women expected to live to 48 and 51 years respectively. But life expectancy is now 74 and 80 years and could be significantly longer with anti-aging advancements currently being developed. At the same time, 30 new highly infectious diseases have been discovered in the last 20 years. These diseases account for 30% of the deaths worldwide and include HIV/AIDS, Ebola, Cancer, and the Avian Flu. The important and major area of nanotechnology research is in human health and is making tremendous progress in the medical field. Some of the nanotechnology applications in the arena will be inexpensive and rapid diagnostics, new methods of drug delivery, and faster development of new drugs. Some longer term and even more powerful nanotechnology solutions will repair DNA and cellular damage and customize drug therapy. Nanotechnology may have its biggest impact on the medical industry compared to other industries. Patients will drink fluids containing nanorobots programmed to attack and reconstruct the molecular structure of cancer cells and viruses. There's even speculation that nanorobots could slow or reverse the aging process, and life expectancy could increase significantly. Nanorobots could also be programmed to perform delicate surgeries such nanosurgeons could work at a level a thousand times more precise than the sharpest scalpel. By working on such a small scale, a nanorobot could operate without leaving the scars that

conventional surgery does. Additionally, nanorobots could change the physical appearance of human beings. They could be programmed to perform cosmetic surgery, rearranging the atoms of human body to change his/her ears, nose, eye color or any other physical feature he/she wish to alter (Cattaneo, 2010).

(8) Environment & Climate : There is an ever-increasing demand for natural resources and living space for humans, while toxics continue to build up in our water and soil. Biodiversity is being destroyed worldwide with 7 million hectares of forest being lost annually. Half of our world's forests and a quarter of our coral reefs are gone. With increasing threats especially to the oceans, biodiversity decreases each year. Damage to the atmosphere's ozone layer has slowed but a hole still remains. Many believe that man-made greenhouse gases are causing disruption to the planet's climate, a process popularly termed 'global warming.' Proposals to correct this are expensive and unlikely to be followed by developing nations who see economic advance as more urgent. Nanotechnology will provide solutions through precision pollution monitoring using nanosensors, lower energy needs due to lightweight strong materials, and reducing the use of harsh cleansers through the applications of nanocoatings to surfaces. A more advanced nanotechnology solution will be building our products with molecular-level precision through the use of productive nanosystems, resulting in virtually no chemical waste and pollution (Diallo, 2011).

III. Challenges for Human Comfortability

(1) Sustainable transportation :

Nanotechnology will become a key enabling platform technology for next generation transportation systems to develop more efficient and lighter materials for automotive and aircraft systems, High performance tyres for automobiles, efficient and non-platinum based catalytic converters, novel more efficient fuel and power sources etc.

(2) Information communication technology for everybody :

There are currently many people who lack widespread access to communications, information, basic technology services and tech resources. This lack of access creates insurmountable barriers to education, democratization, and economic growth. The use of nanotechnology applications will drastically reduce the cost and increase the performance of memory, displays, processors, solar powered components, and embedded intelligence systems. It will also enable networks to be self-configuring. These improvements would

create a pervasive computing environment that would promote greater global communication, cross-cultural understanding and cooperation (Hullmann, 2007).

(3) Consumer Products :

There are many consumer products using nanotechnology on the market. But nanotechnology or nanomaterials in these products are not easy to recognize. Because nanomaterials are embedded into other materials or used in very small amounts, consumers may not be aware of their presence. The various products comes under this category are cosmetics, products used in home and garden, sports, Textiles and Apparel, Cosmetic manufacturers use nanoscale versions of ingredients to provide better UV protection, deeper skin penetration, long-lasting effects, increased color and finish quality etc. (Kimbrell, 2006).

(4) Entertainment :

Nanotechnology is expected to improve home entertainment electronics, 3D televisions, performance of videogames etc. Macro-scale integrated nanotechnology manufacturing systems will improve product functionality, product design time and manufacturing speed and cost by orders of magnitude. This advance may profoundly affect economics and geopolitics, creating enormous benefits and risks. It will be difficult to prepare adequately for such a powerful technology.

(5) Medicine :

The applications of nanotechnology in pharmacy supports preparation of drugs containing nano-sized active ingredients, breakthrough drug delivery systems that allow deposition of medications in previously inaccessible areas of the body, and improved diagnostic tests and medical devices. Nanotechnology in the form of nanoparticles has great potential in the drug delivery field. The main advantage of using nanoparticles for drug delivery is the specific delivery of drug in the targeted organ without affecting the non-targeted organs. In this way side-effect of the drugs can be minimized. In the coming year's advancements in this field will led to an improved form of drug delivery as well as other prospects of medicine and pharmacy.

(6) Manufacturing :

Nanofactories-manufacturing systems that work on the atomic & molecular scale-are gradually moving from science fiction to science fact and one day could be used to build all types of items such as drugs, semiconductor chips and even cell-sized robots that patrol the human body. The first step would be to develop nanoscopic machines, called assemblers that scientists can program to manipulate atoms and molecules at their will. In order to make molecular manufacturing to be reality, one would need trillions of assemblers working together simultaneously. It is predicted that assemblers could first replicate themselves, and then build other assemblers. Each generation would build another, resulting in exponential growth until there are enough assemblers to produce objects. Trillions of assemblers and replicators could fill an area smaller than a cubic millimeter, and could still be too small for us to see with the naked eye. Assemblers and replicators could work together to automatically construct products, and could eventually replace all traditional labor methods and create a method of three dimensional material/device printer. This could vastly decrease manufacturing costs, thereby making consumer goods plentiful, cheaper and stronger. Eventually, such 3D printers allow us to replicate anything, including diamonds, water and food. Famine could be eradicated by machines that fabricate foods to feed the hungry (Hocken, 1993).

(7) Space-travel : The challenges facing by humanity on the earth are the result of our heavy demand on various resources and raw materials. Many of these materials can be found in space but the expense to extract them is a major barrier. In addition to cost, other obstacles to developing space are safety, reliability, and performance. According to the National Space Society there are four reasons why we need to pursue space exploration and colonization. These reasons—survival, growth, prosperity and curiosity—all point to the fact that we, as a species, want more room. Space exploration will give us a means to monitor the health of our planet, a source of resources and an outlet for our imagination. Nanotechnology will create the ability for humans to operate in space more safely. Applications where nanotechnology will impact space exploration are propulsion fuels, coatings, structural materials, smart uniforms, electronics and life support environments. These will be more efficient, stronger, self-healing and lighter than what is currently available.

(8) Extended life span : There are two ways in which nanotechnology may be able to extend our lives. One is by helping to eradicate life-threatening diseases such as cancer, and the other is by repairing damage to our bodies at the cellular level--a nano version of the fountain

of youth. The most exciting possibility exists in the potential for repairing our bodies at the cellular level. Techniques for building nanorobots are being developed that should make the repair of our cells possible. For example, as we age, DNA in our cells is damaged by radiation or chemicals in our bodies. Nanorobots would be able to repair the damaged DNA and allow our cells to function correctly. This ability to repair DNA and other defective components in our cells goes beyond keeping us healthy: it has the potential to restore our bodies to a more youthful condition. The extension of the human lifespan could be facilitated through the removal of a substance called lipofuscin from certain types of non-dividing cells, including the brain, heart, liver, kidneys and eyes. Lipofuscin is a metabolic end product that accumulates primarily within lysosomes (the garbage disposal organelles within cells). It's thought that when lipofuscin accumulates to certain levels, it begins to negatively impact cell function, which eventually manifests in many age related conditions. Aubrey de Grey et al. have proposed that soil bacterial enzymes might have the capacity for degrading lipofuscin. It is proposed that humans might live as long as 1,000 years under the appropriate rejuvenative therapies. In 30 or 40 years, we'll have microscopic machines travelling through our bodies, repairing damaged cells and organs, effectively wiping out diseases. The nanotechnology will also be used to back up our memories and personalities. This strongly make us to believe that in 35 to 40 years, we literally will be immortal (Gelles, 2009).

IV. Nanotechnology based Innovative Solutions

(A) Nanotechnology as Ideal Technology :

An ideal technology system should have characteristics to fulfil its objectives to solve all problems of human beings including both basic needs and advanced gadgets to support comfort living to realize their dreams. Based on various factors which decides the ideal technology system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements (Aithal and Shubhrajyotsna, 2015"b"). The input Conditions include properties like : (1) Manipulate the fundamental nature of matter to provide solutions to basic and advanced problems of mankind, (2) In-expensive & self reliable in terms of resources to make it attractive to be used by people/countries of varied economical situations. (3) Ubiquitous so that the technology provide solutions and services at anytime, anywhere, any amount of time to the users. (4) Affordable to everybody so that it uses common materials available in nature and manipulate effectively to the need of human being at affordable cost.

The Output Conditions include the characteristics like : (1) Solve basic needs like food, drinking water, renewable energy, clothing, shelter, health and clean environment. (2) Provide comfort life to the users by providing solutions to their desires. (3) Equality ; ideal technology provide equal opportunity and similar solutions to every user irrespective of their gender, religion, background, education, economic status, and country of origin. (4) Automation; ideal technology automate all processes in every type of industries to avoid human interference in work/control in order to provide expected output based on programming. (5) Immortality is the ultimate goal of ideal technology so that it can create an avenue for deathless situation or enhancement of human life span.

The System Requirement needs properties like : (1) General purpose technology to support all fields and problems of human & living beings on the earth. (2) Self-directed & self controlled & self regulated so that the technology can control itself in order to achieve its goal. (3) Easy, simple, quick & user friendly to solve all type of problems and to provide quick ideal solution. (4) Scalable so that it is used for solving small and simple problem to large and complex problems of life. (5) Omni-potent to identify and solve problems and provide comfortability to human being and feeling him like God. (6) Exploring new opportunities to improve and explore comfortability and further leisure in life of people. (7) Infinite potential for further development of life in the universe.

Table 1 : Comparison of nanotechnology with ideal technology model (Aithal and Shubhrajyotsna, 2015”b”).

S. No.	Major Problems of human beings in the Society	Ideal technology solution	Nanotechnology solution
1	Nutritious food for everybody	Basic feature of Ideal technology	Possible to solve using nanotechnology in agriculture.
2	Clean drinking water for everybody	Basic feature of Ideal technology	Possible to solve using nanotechnology filters
3	Renewable energy at affordable cost	Basic feature of Ideal technology	Possible through nanotech solar cells & battery technology
4	Quality and long lasting cloth	Basic feature of Ideal technology	Possible to solve using nanotechnology in fabrics.
5	Affordable Shelter to every body	Essential feature of Ideal technology	Possible to solve using nanotechnology in construction.
6	Health care	Basic feature of Ideal technology	Possible to solve using nanotechnology in medicine.
7	Environment & climate	Essential feature of Ideal technology	Possible to solve using nanotechnology as clean technology.
8	Sustainable technology for every body	Essential feature of Ideal technology	Due to its fundamental nature, nanotechnology is sustainable for everybody and everywhere.
9	Comfort life	Luxurious feature of Ideal technology	Possible to solve using nanotechnology in customer products & ability to upgrade all other technologies.
10	Space travel	Luxurious feature of Ideal technology	Nanotechnology supports low cost & efficient space travel.
11	Life span expansion	Desirable feature of Ideal technology	Bio-medical applications of nanotechnology supports life span expansion.

The Environment Conditions include : (1) Maintain clean environment through its processes and avoids foot print of processes while achieving specific function. (2) Infinite business opportunities by creating new products / services with ideal characteristics. (3) Adaptive to any situations to achieve stated goal. (4) No side effects so that it should be safe for users, and environment. Any technology which has the above properties/characteristics is considered as ideal technology and the conventional technologies have serious drawbacks/limitations in terms of the above properties.

The characteristics and opportunities of nanotechnology can be comparable with the above mentioned characteristics of ideal technology. This supports the possibility of realization of Ideal technology using nanotechnology. It is predicted that nanotechnology being a general purpose technology can provide solutions almost all basic and high level problems like hypothetical Ideal technology. Table 1 compares the possible ideal technology solutions with nanotechnology solutions for solving major problems of human being in the society (Aithal and Shubhrajyotsna, 2015''b'').

(B) Nanotechnology as Breakthrough Technology of 21st Century :

Nanotechnology is considered as anticipated breakthrough technology of 21st century and is spreading quickly as disruptive technology to all areas of the society. A disruptive technology

is a new technology that is significantly cheaper than current, and/or is much higher performing, and/or has greater functionality, and/or is more convenient to use. A disruptive technology will revolutionize worldwide markets by superseding existing technologies. Disruptive technology sounds negative to only organizations that are unprepared for change, and fail to adapt, only to fall behind, and ultimately disappear. The results are not just *evolutionary*, they are *revolutionary*. Nanotechnology is going to be general purpose technology like information technology. It has wonderful features, which are not present in any other technology. Some of other anticipated technology breakthrough also depends on innovations in nanotechnology like Optical Computation, Embedded Intelligence, Chameleon Chips, Flying cars, Immortality through nano-bio-technology, and Space travel (Aithal and Shubhrajyotsna, 2015" a"). The phenomena, which were not possible few years back, are now easily implemented with the help of nanotechnology. Some of the nanotechnology based products features are described below :

(1) Nanosensors :

Nano-sensors are used for toxins in food, proteins, water; viruses, bacteria, pollutants in water, bioprocess monitoring, process control, biochemicals, intracellular activity, sensors on foods for tracking, Some of the nano-sensors are (Gupta, 2012) :

(a) Nanobiosensors: The nanosensors with immobilized bioreceptors probes which are selective for target analyte molecules are called nanobiosensors. These can be integrated into other technologies like lab-on-a chip to facilitate molecular diagnostics. Their applications include detection of microorganisms in various samples, monitoring of metabolites in body fluids and detection of tissue pathology such as cancer. Their portability makes them ideal for POC applications but they can also be used in laboratory settings.

(b) Nanowire biosensors: Surface properties of these can be easily modified therefore they can be decorated with virtually any potential chemical or biological molecular recognition unit, thus making the wires themselves analyte independent. Boron doped silicon nanowires are used to create highly sensitive, real time electrically based sensors for biological and chemical species.

(c) Viral nanosensors: Essentially the virus particles are called as biological nanoparticles. Herpes Simplex Virus (HSV) and adenovirus have been used to trigger the assembly of

magnetic nanobeads as a nanosensor for clinically relevant viruses. By using a magnetic field, as few as five viral particles can easily be detected in a 10 ml serum sample.

(d) **PEBBLE nanosensors:** Probes encapsulated by Biologically Localized Embedding (PEBBLE) nanosensors consists of sensor molecules which are entrapped in a chemically inert matrix by a microemulsion polymerization process that produces spherical sensors in the size range of 20 to 200 nm. These are capable of real time inter and intracellular imaging of ions and molecules and are insensitive to interference from proteins.

(e) **Optical biosensors:** Many biosensors which are currently marketed rely on the optical properties of lasers to monitor and quantify interactions of biomolecules that occur on specially derived surface or biochips. Example: Surface plasmon.

(f) **Laser nanosensors:** In this laser light is launched into the fibre and the resulting evanescent field at the tip of the fiber is used to excite target molecules bound to the antibody molecules. When laser falls on them, they release optical signals which are coded by photometric detection system. This system is used in analysis of proteins and biomarkers in human living cells.

(2) Shaping memory materials

Nanotechnology introduced the techniques to distort the plastic and silicon structures, which allowed the recovering of original shape of the material. This technology is named as SMM shaping memory materials. Metals and aluminum are reshaped and processed at nano scale to produce a chip, which can store bulk of information on it. Aluminum and silicon distortion was impossible before the arrival of nanotechnology

(3) Assemblies and Chemical sensitivity of porphyrin

Porphyrins is the element with the unique binding properties that are widely exploited in natural world to attain beneficial and essential functions for life, nanotechnology has provided the most accurate and real some the mimic of these functions with synthetic counterparts which provides the basis of chemical bonding and sensitizing

(4) Metal oxide nano-wires as chemical sensors

Another impressive feature of nanotechnology is that it made possible for the scientists to use metal oxides as the sensors. When metal are treated at nano scale they can carry huge amount of electrons and can be used as chemical sensors, as was discovered in early nineties and nano-wires were introduced.

(5) Use of nano-materials for water purification

Nanotechnology allowed the researchers to process the materials to be used in purification of drinking water such as sand, soil and even glass. Nano filtration plants are present in the developed countries of the world. Nano materials can purify water up to 99.9 percent without affecting the original flavor the water. It was seen for the first time that nanotechnology can extract the safest drinking water.

(6) Self-assembling

Self-assembling the key feature of nanotechnology. There is no other technology in which molecules under processing can rearrange themselves easily. Molecular nanotechnology can produce many new components from the existing ones by simply rearranging themselves.

(7) Miniaturizing mechanical surgery

Recent advances in sub-millimeter scale engineering showed the excellent work of nanotechnology in the field of medical sciences .nanotechnology introduced such devices, which do not even leave a scar after major surgeries. it has also miniaturized the surgical instruments which are used in the diagnostics and therapeutics applications.

(8) Fabrication of electronic biosensors

Nanotechnology introduced the nano fabrications, which has reduced the cost of some of the major health equipment that includes electronic biosensors. Detection biosensors, which are nano- structured, detect and displays highly revolutionized images.

(9) New carbon nanotubes AFM technology

Nanotechnology also has great value in the field of nuclear sciences because of its extra ordinary features to increase the atomic force. it was discovered in mid nineties that uranium if processed at nano level can empower the five times more powerful nuclear bomb. Nanotechnology enlighten the nano particle of carbon, nanotubes of carbon are used to build ultra sharp tips for cutting the rigid surfaces. The technology of the new carbon tubes is named as AFM (Atomic Force Microscopy). The technology is used for the fabrication of probe tips with ultra sharp points. AFM is also used for synthesizing and for developing new components.

(10) General Purpose technology

Nanotechnology can create machines, peripheral home appliances with best functioning until now. It is the only technology, which is general purpose. From Light Emitting Diodes (LEDs) to socks, all are processed at atomic scale for increasing and improving the quality of the product.

V. Nanotechnology based Products

The nanotechnology-based products are now entering the consumer market in a big way. Nanotechnology has tremendous application potential in several areas such as Fast Moving Consumer Goods (FMCG), cosmetics, healthcare, medicine, plastics, composites, coatings, printed electronics, optics, biotechnology, renewable energy and aerospace/ defense among others, where it has offered many opportunities to improve conventional technologies (www.nanotechproject.org).

A wide range of commercialized products containing nano materials are already in the market, in areas like health care, cosmetics and fitness, home and garden appliances, electronics and computers, food and beverages, sports goods, paints, clothing, automotive and aerospace components, etc. Table 2 contains the nanotechnology based product category available in the market along with the sub-categories and number of products in each category.

Table 2 : Information about the nanotechnology based products available in market.

S. No.	Product category	Sub-categories	No. of Products in Market
1	Appliances	1. Batteries 2. Heating, Cooling and Air purifiers 3. Large Kitchen Appliances 4. Laundry & Clothing care	68
2	Automotive	1. Exterior 2. Maintenance & Accessories 3. Watercraft 4. Lubricants	214
3	Cross Cuttings	1. Nano Coatings 2. Bulk Materials	142
4	Electronics & Computers	1. Audio 2. Cameras & Films	101

		<ul style="list-style-type: none"> 3. Computer Hardware 4. Display 5. Mobile Devices & Communications 6. Television 7. Video 	
5	Food & Beverage	<ul style="list-style-type: none"> 1. Cooking 2. Food 3. Storage 4. Supplements 	118
6	Goods for Children	<ul style="list-style-type: none"> 1. Basics 2. Toys & Games 	37
7	Health & Fitness	<ul style="list-style-type: none"> 1. Clothing 2. Cosmetics 3. Filtration 4. Personal care 5. Sporting goods 6. Sunscreen 7. Supplements 	908
8	Home & Garden	<ul style="list-style-type: none"> 1. Cleaning 2. Construction Materials 3. Home furnishings 4. Luggage 5. Luxury 6. Paint 7. Pets 	356

VI. NanoTechnology based Services

A service type of business provides intangible products (*products with no physical form*). Service type firms offer professional skills, expertise, advice, and other similar products. Some of the service business opportunities using nanotechnology developments are listed in table 3.

Table 3 : Service business opportunities using nanotechnology.

S. No.	Nanotechnology based service business	Business Benefits
1	Collaborative services for nanotech product design	Information about collaborative opportunities
2	Safety services for nanotech products usage	Employee monitoring, advancing imaging, better testing, new characterization methods.
3	Security services using nanotech	Tagging and tracking, monitoring, advancing sensors technology, improved RFID technology in body armour, combating fraud with nanoparticle based inks.
4	Consultants service with nanotech cases, nanotech events & others	Nanotechnology consultation based earning opportunity
5	Judicial service for Contract lawyers with a lot of nano specific expertise	Opportunity for Judicial service by lawyers
6	Patent office's service with a lot of nano experience	Consultation opportunity for patent service
7	Nanomaterials R&D service, based on nanomaterials know-how	Latest R & D information and information on emerging products in the market
8	Imports of only nanomaterials & nanodevices	Business opportunity inimport service of nano-materials
9	Analysis service, based on equipments for analysing nanostructures	Opportunity for nanostructure analysis service
10	Coating service, based purely on nano coating on surfaces/devices for specific purpose	Durable coatings of materials surface.
11	Tourism industry - Information speedup services through nanotech based displays at airports	Enhanced displays and user interfaces

VII. Impact of Nanotechnology on Business

Nanotechnology is impacting businesses and expected to offer new and improved products and processes and supports the companies to innovate and enter to the new markets. Nanotechnology will change the way the businesses are being carried on. It will lead to the

emergence of new businesses as well as business practices and also a new role for research & development, completely different types of product & services compared to present day products & services in the market, and intermediaries. Indeed, all the functional areas of business will undergo changes as follows :

- The new technology will transform business processes, the way products and services are created and marketed, dynamics of competitions, the organization structure of the enterprise and the nature of the enterprise itself. This will include product development, production, marketing, supply management, customer and sales management, etc. The market driven business will change as product /services driven business.

- Local proximity and customization may no longer be a significant factor in retaining customer. Local markets will be replaced by global markets based on global products & services. Indeed it may bring to reality the goal of making the whole world as one family by solving the basic problems of human beings. The general universal solutions are possible for most of the basic problems & problems related to comfortable life style.

- Transparency and openness continue and will continue, to be effective business strategy. Already many businesses have started recognizing key customers, employees and suppliers more like a partner in the business. Nanotechnology supported products and services will lead to better customer service, more personalized products, reduced costs, supply chain efficiency and faster time to market due to their effectiveness to all people irrespective of region (country), religion, community, gender and age. The most significant aspect of nanotechnology is new market creation for newly developed products and services which are going to be the part & parcel of everybody's life.

- The change in the business functions will lead to new business models and create new set of facts and circumstances that can materially change the economy and world growth rate.

- The nano-trend will emerge as a new platform for marketing of products and services that will displace and rebuild existing economy. It will affect organizational structure; require different skills for negotiation, new regulatory and legal framework, new environmental policy, taxation and many other things. The evolution of nanotechnology will have profound impact on competition, mobility of enterprises, effect on consumer behavior, changes in the way the work is defined and managed. The advantages and benefits of nanotechnology products & services in parallel with advents of online communication & internet technology

will enable businesses to save time on product design, design according to the individual customer specification, order and delivery of components, tracking sales and getting feedback from customers.

- The businesses can have virtual project team to develop and customize nanotechnology products, virtual learning space so that the employees of the companies for product design, development and marketing, who are dispersed over various countries can work together as if they are together in one physical room. Business can be connected to the retail points in order to ascertain market trends, demand of the products and with the suppliers upstream to order the desired requirements. Better demand forecasting and stock replenishment based on educating the people online to create greater demand due to incredible advantages of nanotechnology products leads to large scale production which intern can lead to significant reduction in the cost.

- By means of educating more people to understand the advantages and benefits of nanotechnology based products and services, the nanotech companies and the country Government can create awareness among the people to en-cash the potential benefits in the process of solving both fundamental problems and problems related to luxurious life leading without much human efforts.

(1) Impact on production :

Design of nanotechnology products with tailored properties as per the requirement in the market is greater challenge for organizations. This also includes the production at greater efficiency to meet demand by means of automation to increase efficiency, controlling the wastage and to maintain the standard quality.

(2) Impact on marketing :

Product promotion Nanotechnology based solutions enhances promotion of products due to their attractive features which have to be advertised properly to attract many customers.

Corporate image : The innovative products and services based on nanotechnology will attract many customers so that newcomers started the business can establish corporate images very quickly. Corporate image means trust, which is necessary for direct sales.

(3) Impacts on organizations :

Technology and Organizational Learning: Rapid progress in nanotechnology based products & services will force companies to adapt quickly to the new technology and offer them an opportunity to experiment with new products, services, and processes. To be more flexible and responsive to the market, new processes must be developed. This type of corporate change must be planned and managed.

Changing Nature of Work: The nature of work and employment in the organizations will be transformed due to this disruptive technology. Driven by increased competition in the global marketplace, firms are reducing the number of employees down to a core of essential staff and outsourcing whatever work they can to countries where wages are significantly less expensive.

New product capabilities: Nanotechnology allows for new products to be created and customized in innovative ways. Such changes may redefine organizations' missions and the manner in which they operate. Mass customization enables manufacturers to create specific products for each customer, based on his or her exact needs.

(4) Impact on Economy :

The nanotechnology enables firms to produce global standardized products which are capable to solve both basic needs and comfortable life leading requirements at very low cost, the poverty will be eradicated and the people irrespective of their country of origin, irrespective of natural resources they have geographically, prosper and lead a happy life. As a result, the economy of all the countries will grow in exponential manner.

(5) Impact on Social life :

Due to its capabilities of solving both fundamental and esteem needs of human beings, nanotechnology changes both life-style and social life of human beings. The differentiation of people based on his or her financial conditions/status will disappear. All people of the world become tech savvy and become matured in thinking of equality and lead happy life. All types of social evils, sufferings due to ill-health will reach to an end.

VIII. Conclusion

The applications of nanotechnology in different identified areas provide lots of business opportunities. It includes Food, Medicine, Cleaner water, Better quality air, Electronics, Fuel Cells, Solar Cells, Batteries, Space Travels, Chemical sensors, Sporting goods, Fabrics,

Cleaning products, Energy, Environment, Health, and Life span increase. The paper covers the applications, benefits and uses of nanotechnology innovations in different industries, possible business opportunities for new nanotechnology based products and services due to challenges for human prosperity on earth, the impact of nanotechnology on business, with an expected time scale and future possibilities of nanotechnology innovations and the magic (like science fictions) going to happen in human life. It is also discussed that how nanotechnology is going to be a disruptive innovation by solving all problems in the society like food, energy, drinking water, health and environment and rendering human life limitless.

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