Novel Aspects in Nanotechnology: Applications and Future Challenges in Computer Science

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Abstract:Now-a-days nanotechnology is strengthening its roots in the field of computer science by contributing in the creation of more efficient computing components. Nanotechnology has been developed by many research areas and several fields like Physics, Chemistry, Biology, Material Science, Engineering and Computer Science. This paper shows how these nanotechnology tools and devices can be used to benefit information technology industry and we look applications, currentscenarios of nanotechnology in computer science and the future of nanotechnology research areas in computer science. In this paper we explore the development and advancement of nanotechnology which provides ample opportunity to develop a smaller, faster and reliable computer.

Keywords: *Nanotechnology, Computing, DNA Computing, Memory Storage, Semiconductors etc;*

1. Introduction to Nanotechnology

Nanometer is a unit of length in the metric system, equal to one billionth of a metre (10-9).Technology is the making, usage and knowledge of tools, machines and techniques, in order to solve a problem or perform a specific function. Nanotechnology is the study of manipulating matter on an atomic scale. Nanotechnology refers to the constructing and engineering of the functional systems at very micro level or we can say at atomic level. A Nanometer is one billionth of a meter, roughly the width of three or four atoms. The average human hair is about 25,000 nanometers wide. Nanotechnology concept was presented in 1959 by the famous professor of physics Dr. Richard P.Feynman Invention of the scanning tunneling microscope in 1981 and the discovery of fullerene (C60) in 1985 lead to the emergence of nanotechnology. The term “Nanotechnology" had been coined by Norio Taniguchi in 1974. The early 2000s also saw the beginnings of commercial applications of nanotechnology, although these were limited to bulk application of nanomaterials.Silvernano platform for using silver- nanoparticles as an antibacterial agent, nanoparticle-based transparent sunscreens, and carbon nanotubes for stain-resistant textiles.

1.1. How Nanotechnology can affect on the computer applications?

Nanotechnology is a very broad area of study and research at present. It has been developed by many researchers and includes several fields of study like physics, chemistry, biology, material science, engineering and computer science. Some applications are given below:

1. Medicine (Diagnostic, Drug delivery, tissue engineering) •

2.Cryonics

3.Environment

4. Energy (Reduction of energy consumption, increasing the efficiency of energy production, nuclear accident clean up and waste storage)

5 Information and communication (memory storage, novel semiconductor devices)

6. Heavy industry (aerospace, catalysis, construction)

7. Consumer goods (Food, nanofoods, household, optics, textiles, cosmetics, agriculture and sports)

1.2 Faster, lighter computers possible with nanotechnology

Smaller, lighter computers and an end to worries about electrical failures sending hours of on-screen work into an inaccessible limbo mark the potential result of Argonne research on tiny ferroelectric crystals.

"Tiny" means billionths of a meter, or about 1/500th the width of a human hair. These nanomaterials behave differently than their larger bulk counterparts. Argonne researchers have learned that they are more chemically reactive, exhibit new electronic properties and can be used to create materials that are stronger, tougher and more resistant to friction and wear than bulk materials.

1.3.*Computing applications*

RAM – random access memory – is used when someone enters information or gives a command to the computer. It can be written to as well as read but - with standard commercial technology - holds its content only while powered by electricity.

Argonne materials scientists have created and are studying nanoscale crystals of ferroelectric materials that can be altered by an electrical field and retain any changes.

Ferroelectric materials – so called, because they behave similarly to ferromagnetic materials even though they don't generally contain iron – consist of crystals whose low symmetry causes spontaneous electrical polarization along one or more of their axes.

Because the crystals do not revert spontaneously, RAM made with them would not be erased should there be a power failure. Laptop computers would no longer need back-up batteries, permitting them to Achieving such permanence is a long-standing dream of the computer industry."Companies such as AT&T, Ford, IBM, RCA and Westinghouse Electric made serious efforts to develop non-volatile RAMs in the 1950s, but couldn't achieve commercial use," said Argonne researcher Orlando Auciello. "Back then, NVRAMs were based on expensive ferroelectric single crystals, which required substantial voltage to switch their polarity.

1.4Memory storage:

Memory storage before the advent of nanotechnology relied on transistors, but now reconfigurable arrays are formed for storing large amount of data in small space. For example, we can expect to see the introduction of magnetic RAMs and resonant tunnel elements in logical circuits in the near future. Every single nanobit of a memory storage device is used for storing information. Molecular electronics based on carbon nanotubes or organic macromolecules will be used.

1.5Semiconductors:

Nano amplification and chip embedding is used for building semiconductor devices which can even maintain and neutralize the electric flow. Integrated nanocircuits are used in the silicon chips to reduce the size of the processors. Approaches promising success in the medium term include e.g. rapid single-flux quantum (RSFQ) logic or single electron transistors.

1.6Display and audio devices:

Picture quality and resolution of display devices has improved with the help of nanotechnology. Nanopixilations of these devices make the picture feel real. Similarly frequency modulation in audio devices has been digitized to billionth bit of signals.

1.7Data processing and transmission:

In the field of data processing and transmission development of electronic, optical and optoelectronic components are expected to lead to lower cost or more precise processes in the field of manufacturing technology. Development of nanoscale logical and storage components are made for the currently dominant CMOS technology using quantum dots and carbon nanotubes. Photonic crystals have potential for use in purely optical circuits as a basis for future information processing based solely on light (photonics).

2. Future nanotechnology areas

Nanotechnology is the next industrial revolution and the telecommunications industry will be radically transformed by it in the future. Nanotechnology has revolutionized the telecommunications, computing, and networking industries. The emerging innovation technologies are:

- ✓ Nanomaterials with novel optical, electrical, and magnetic properties
- ✓ Faster and smaller non-silicon-based chipsets, memory, and processors
- ✓ New-science computers based on Quantum Computing
- ✓ Advanced microscopy and manufacturing systems
- ✓ Faster and smaller telecom switches, including optical switches
- ✓ Higher-speed transmission phenomena based on plasmonics and other quantum-level phenomena
- ✓ Nanoscale MEMS: micro-electro-mechanical systems

2.1Why we use nanotechnology in computer

The extensive use of computer and its wide application in the modern world have forced the researchers to improve and manufacture a small and a more reliable computer.

2.2. Impact on Modern Computer

Faster and Smaller: By replacing silicon transistor with transistor based on nanotubes we will get faster, smaller and less energy consuming computer.

Increase the speed:

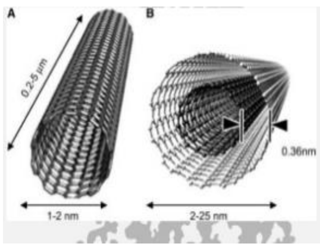
The most common semi conductor or material transistors are silicon, since it is cheap and easy to process. But Silicon has its limitations. By exchanging the silicon in the channel for a carbon nanotube, the transistors can be made both smaller and faster than today's transistors. The basic concepts that links nanotechnology to computer science just like many other applications is when materials are scaled to the nano level they develop various tunable and desirable properties such as optical, electronic, mechanical, magnetic which are otherwise absent in bulk materials.

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. Nanotechnology is already in use in many computing, communications and other electronics applications. The extensive use of computer and its wide application in the modern world have forced the researchers to improve and manufacture a small, faster and a more reliable computer.

<u>3.Current Scenarios of Nanotechnology and Computer Science</u>

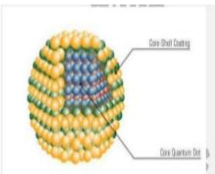
The impact of nanotechnology on computers has a few unique twists; which are mainly in the research and development phases. Here are examples of how nanotechnology has changed computer and its various aspect:

3.1 Carbon Nanotube Compute



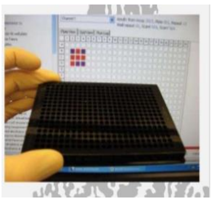
Carbon nanotubes (CNTs) are hollow cylinders composed of a single sheet of carbon atoms. It has been observed that CNT has same property as Silicon transistor and thus they act as semiconductor which makes them suitable for being used as transistor in computer chips. A team of Stanford engineers has built a basic computer using carbon nanotubes, which has the potential to make a new generation of electronic devices that run faster, and makes use of less energy, as compared with silicon chips. This nanotube processor is made up of 178 transistors, each of which contains carbon nanotubes that are about 10 to 200 nanometer long. It has been reported by the they have made six versions of carbon nanotube computers, out of which one them can be connected to external hardware, and a numerical keypad that can be used to input numbers for addition.

3.2 Quantum Computing



Quantum computing may well be the future of most high-end data centers. These future computers are not based upon digital 1's and 0's. Instead these future computers are based upon bits (quantum bits). The power of magnetic forces at a subatomic scale will unleash the exponential power of future computers. By manipulating the rotation of atoms, data can be transmitted and stored at an unprecedented rate. Physicists have found a way to extend the quantum lifetime of electrons by more than 5,000 per cent. Electrons exhibit a property called 'spin' and work like tiny magnets which can point up, down or a quantum superposition of both. The state of the spin can be used to store information and so by extending their life the research provides a significant step towards building a usable quantum computer.

3.3 DNA Computing



DNA computation is based on the fact that technology allows us to 'sequence' (design) single DNA strands which can be used as representations of bits of binary data. Technology also allows us to massively 'amplify' (reproduce) individual strands until there are sufficient numbers to solve complex computational problems. DNA molecule has a double helix structure composed of two sugar phosphate backbones formed by the polymerization of deoxy-ribose sugar. Placed between two backbones are pairs of nucleotides Adenine, Cytosine, Guanine and Thymine. DNA computers use single strands of DNA to perform computing operations. DNA computing focuses on the use of massive parallelism, or the allocation of tiny portions of a computing task to many different processing elements. The structure of the DNA allows the elements of the problem to be represented in a form that is analogous to the binary code structure. Trillions of unique strands of DNA are able to represent all of the possible solutions to the problem. Some scientists predict a future where our bodies are patrolled by tiny DNA computers that monitor our well-being and release the right drugs to repair damaged or unhealthy tissue.

3.4 NVRAM (Non Volatile RAM)

Is computer memory that can get back stored information even when not powered examples of non-volatile memory include read only memory, flash memory, ferroelectric RAM. Using NVRAM laptop computers would no longer need back up batteries, permitting them to be made still smaller and lighter. This achievement of nanotechnology is considered as a long-standing dream of the computer industry.

4. Nanotechnology Applications

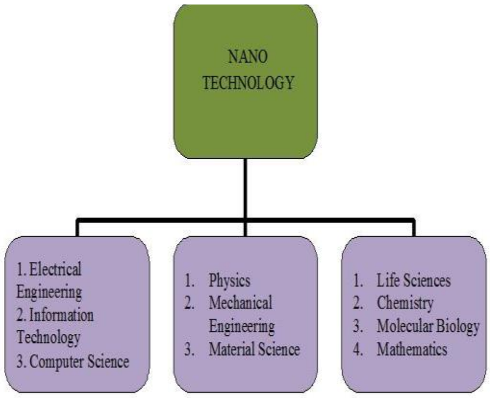


Fig :Applications of nanotechnology in various Domains

4.1 <u>Medicine</u>

Researchers are developing customized nanoparticles the size of molecules that can deliver drugs directly to diseased cells in your body. When it's perfected, this method should greatly reduce the damage treatment such as chemotherapy does to a patient's healthy cells.

4.2 <u>Electronics</u>

Nanotechnology holds some answers for how we might increase the capabilities of electronics devices while we reduce their weight and power consumption.

4.3 <u>Food</u>

Nanotechnology is having an impact on several aspects of food science, from how food is grown to how it is packaged. Companies are developing nanomaterials that will make a difference not only in the taste of food, but also in food safety, and the health benefits that food delivers.

4.4 <u>Fuel Cells</u>

Nanotechnology is being used to reduce the cost of catalysts used in fuel cells to produce hydrogen ions from fuel such as methanol and to improve the efficiency of membranes used in fuel cells to separate hydrogen ions from other gases such as oxygen.

4.5 Better Air Quality

Nanotechnology can improve the performance of catalysts used to transform vapors escaping from cars or industrial plants into harmless gasses. That's because catalysts made from nanoparticles have a greater surface area to interact with the reacting chemicals than catalysts made from larger particles. The larger surface area allows more chemicals to interact with the catalyst simultaneously, which makes the catalyst more effective.

4.6 Cleaner Water

Nanotechnology is being used to develop solutions to three very different problems in water quality. One challenge is the removal of industrial wastes, such as a cleaning solvent called TCE, from groundwater. Nanoparticles can be used to convert the contaminating chemical through a chemical reaction to make it harmless. Studies have shown that this method can be used successfully to reach contaminates dispersed in underground ponds and at much lower cost than methods which require pumping the water out of the ground for treatment.

4.7 Chemical Sensors

Nanotechnology can enable sensors to detect very small amounts of chemical vapors. Various types of detecting elements, such as carbon nanotubes, zinc oxide nanowires or palladium nanoparticles can be used in nanotechnology-based sensors. Because of the small size of nanotubes, nanowires, or nanoparticles, a few gas molecules are sufficient to change the electrical properties of the sensing elements. This allows the detection of a very low concentration of chemical vapors.

4.8 Sporting Goods

If you're a tennis or golf fan, you'll be glad to hear that even sporting goods has wandered into the nano realm. Current nanotechnology applications in the sports arena include increasing the strength of tennis racquets, filling any imperfections in club shaft materials and reducing the rate at which air leaks from tennis balls.

4.9 Fabric

Making composite fabric with nano-sized particles or fibers allows improvement of fabric properties without a significant increase in weight, thickness, or stiffness as might have been the case with previously-used techniques.

5. Benefits of nanotechnology for computer science

Nanotechnology has benefited computer science in many ways such as by increasing the efficiency of computer processors, by ensuring the continuity of MOORE'S LAW etc. A billion (or trillion) tiny particles, whether complex molecules or miniature machines, must all cooperate and collaborate in order to produce the desired end result.

Computer science, and especially fields of research such as swarm intelligence, will be critical for the future of bottom-up nanotech. Nanotechnology is already in use in many computing, communications, and other electronics applications to provide faster, smaller, and more portable systems that can manage and store larger and larger amounts of information.

These continuously evolving applications include:Nano scale transistors that are faster, more powerful, and increasingly energy-efficient; soon your computer's entire memory may be stored on a single tiny chip.Magnetic random access memory (MRAM) enabled by nanometer-scale magnetic tunnel junctions that can quickly and effectively save even encrypted data during a system shutdown or crash, enable resume-play features, and gather vehicle accident data.

Displays for many new TVs, laptop computers, cell phones, digital cameras, and other devices incorporate nanostructured polymer films known as organic light-emitting diodes, or OLEDs. OLED screens offer brighter images in a flat format, as well as wider viewing angles, lighter weight, better picture density, lower power consumption, and longer lifetimes.

6. TEN ways Nanotechnology impacts out lives on a daily basis

1. 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.

2. Faster, more functional and more accurate medical diagnostic equipment. This technology enables point-of-care testing in real time, which speeds up delivery of medical care. Nanomaterial surfaces on implants improve wear and resist infection.

3. In the 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 parts from nano 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.

5. Nanoparticles are 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.

6. 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.

7. Commercial use of Carbon Nano tubes 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

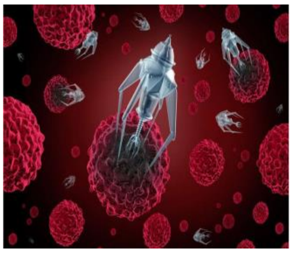
delivery. Nanoparticle-treated tennis balls can keep bouncing twice as long as standard tennis balls.

8. 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.

9. 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.

10. 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. Nano sensors can also be used to accurately identify particular cells or substances in the body.

6.1 Five ways nanotechnology is securing your future



6.1.1 Doctors inside your body

Wearable fitness technology means we can monitor our health by strapping gadgets to ourselves. But by scaling down this technology, we could go further by implanting or injecting small sensors inside our bodies. 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..

6.1.2 Sensors, sensors, everywhere

Nano materials and manufacturing techniques are newly invented in sensors relay to make them smaller, more complex and more energy efficient. For example, sensors with very fine features can now be printed in large quantities on flexible rolls of plastic at low cost. Critical infrastructure opens up the possibility of placing sensors at lots of points constantly check that everything is running correctly. Nuclear power plants Bridges and even aircrafts could benefit.

6.1.3. Self-healing structures

If cracks do appear then nanotechnology could play a further role. Changing the structure of materials at the nanoscale can give them some amazing properties – by giving them that repels water with a texture that, for example. In the future, nanotechnology coatings or additives will even have the potential to allow materials to "heal" when damaged or worn. For example, dispersing nanoparticles throughout a material means that they can migrate to fill in any cracks that appear. Aircraft cockpits to microelectronics could produce self-healing materials for everything.Preventing small fractures from turning into large, more problematic cracks.

6.1.4 Making big data possible

All these sensors will produce more information than we've ever had to deal with before – so we'll need the technology to process it and that will alert us to problems. The same will be true if we want to use the traffic sensors from "big data" to help manage congestion and prevent accidents, or prevent crime by using statistics to more effectively allocate police resources. Here, Creation of Ultra-dense memory nanotechnology is helping that will allow us to 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. The big-data processes having example for efficiently being performed in real-time by tiny structures..

6.1.5. Tackling climate change

The Climate change means we need new ways to generate and use electricity, and nanotechnology is already playing a role. It has helped create batteries that can store more energy for electric cars. This means that there is more space for the reactions that enable energy storage or generation to take place, so the devices operate more efficiently

In the future, nanotechnology could also enable objects to harvest energy from their environment. Producing energy from movement is new nano-materials concepts that are currently being developed that show potential for producinglight, variations in temperature, glucose and other sources with high conversion efficiency.

6.2. Scope of Nanotechnology in India and Abroad

India: India is still in the development stage for Nanotechnology and it will take quite a few years for this field to become established in India. Research labs and institutions such as IISC, TIFR, NCBS, IITsetc are performing excellent research in India. However, when compared with countries such as UK, Germany and USA, output of high quality research pales significantly. This is due to several reasons such as lack of integration between different departments for R&D in Nanotechnology.

Abroad: Nanotechnology is doing very well abroad in nations such as USA, UK, Singapore, Germany, China etc in terms of R&D. There has been significant development towards the usage of Nanotechnology in cosmetics, food and textiles. Nanomedicine is still in the R&D stage and widespread growth is yet to be expected and intensive research is being conducted in breakneck speed.

7. Conclusion and Future Scope

Nanotechnology will be able to improve scientific exploration by far simply because nanites are so small.This paper intended to describe the role of nanotechnology in the department of sophisticated small computers also the paper is described the dependency of particular section or field of nanotechnology which is directly related to the development of an advance computer in future. This paper can give gentle hope to make the research in multideceplain field using nanotechnology. The current trends and the future development will lead to huge contribution in the field of computer science.Today nanotechnology being in the fourth generation of evolution is likely to show outstanding innovations in near future.This will increase the quality of life in our society.

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