Role of Nanotechnology in Emergence of New Computing World

Akhil Aggarwal[1],
[1]Department of Information Technology,
National Institute of Technology,
Srinagar, India

Aman Aggarwal[2],
[2]Director, Ganga Institute of Technology and Management,
Kablana, Jhajjar, Haryana,
India

Kamal Kumar Ranga[3]
[3] Department of Computer Science & Engineering,
Ganga Institute of Technology and Management,
Kablana, Jhajjar, Haryana, India

***Abstract*:- With the introduction of Nanotechnology in the field of computing there has been a huge revolution in making a smaller size circuits and this hunger to decrease size and increase in functionality of the circuits Nanotechnology is a very broad area of interdisciplinary research that includes several fields of study like Physics, Chemistry, Biology, Material Science, Engineering And Computer Science. With the introduction of Information Technology its influence has led scientists to focus on making IT more efficient. In this paper, we have explored how Nanotechnology is about to bring a major change in computing we do, and how we do by introducing a very fast and more accurate computers. The developments and advancements of nanotechnology keeping prime focus on computing industry and its possible future research and development.**

Keywords: Nanotechnology, nanofabrication, quantum dots, quantum mirage, grapheme, DNA computing.

I. INTRODUCTION

We stand at the threshold of a new scientific and technological evolution, where technology is based on a comprehensive understanding of the structure and behavior of a matter from nanoscale (with very limited functionality) to the most complex system (which is yet to be discovered i.e. HUMAN BRAIN). With unification of science based on unity in nature and its holistic investigation will lead to technological convergence and a more efficient societal structure for reaching human goals. In early decades of 21st century, focused effort can bring nanotechnology and information technology, together. With proper attention to ethical issues and social needs, the result can be a tremendous improvement in human abilities, industries, products and societal outcomes that leads to quality of life.

The Nano-Technology: Nanotechnology can be referred as the science that deals with manipulation of matter on atomic and molecular scale. Nano technology could be a technology that deals with designing, characterization, production and application of structures & devices and systems by a controlled manipulation of size and shape at the nanometer (10^{-9} m) scale comparable to atomic or molecular scale and that produces structures, devices and systems with at least one superior characteristic (functionality).

Information Technology: As defined by Canton (2006) - "Information Technology (IT) is the impact of microchips, computing and Internet tasks, careers, communications, creativity, and entertainment". In today's world, Information Technology hugely affects lives of all human beings, either directly or indirectly. The expeditious exchange of information through technology has greatly changed the human nature and behavior. Their workplace may not necessarily need to be an address as it can be virtual; therefore, the integration of conference phone calls, mobilephones, fax machines, computers and telephone modems, implies that the office can exist anywhere and is accessible anytime.

Nanotechnology in Information Technology: With the advances in Nanotechnology, it has helped Information Technologyby shrinking the size and increasing the device functionalities, specifically the computing and communication devices. We can take example of mobile phone, which was initially a bulky and having basic functionalities of sending and receiving calls to a smart phone which is having smaller size and lighter in weight still it has enormous functionalities. Likewise the size of computers has shrieked from room size to palm size and in future it would be of thumb size. The Nano Technology has also facilitated the mergingof various devices into one that enhanced its portability into Information Technology to exploit its benefits to the fullest.

The Information Technology not only connects people only through work but also facilitate family interactions, since parents can run their business from a home office and care for the children. Among numerous, several positive aspects one of the positive aspects of Information Technology involves shifts among population, as communication becomes so easy, people do not need to live in highly inhabited cities, and they can live anywhere around the world and can match pace with world. [1]

Thus the prime objective of Nano Technology is not only to build machines on molecular scales, but also to integrate this technology into Information Technology to make it more and more beneficial for society and to ease the functionality to the common man.

II. BACKGROUND

THE BEGINNING

The ideas and concepts behind nanoscience and nanotechnology started with a talk entitled "***There's Plenty of Room at the Bottom***" by physicist Richard Feynman at an American Physical Society meeting at the California Institute of Technology (CalTech) on December 29, 1959. In his talk, Feynman has described the process in which scientists would be able to manipulate and control individual atoms and molecules. Later, after a decade, Prof Norio Taniguchi in his explorations onultra precision machining has coined the term *NANOTECHNOLOGY*. The real development of nanotechnology started in 1981, with the development of the scanning tunneling microscope that could be able to see individual atoms, with this there has been exponential growth in the field.

THE GENERATIONS:

Nanotechnology has witnessed four generations till date.

i) First Generation: It is called passive nanostructures.

These materials have steady or quasi-steady structures and functions; such as mechanical behavior and chemical reactivity. Passivephysical properties of the nanotechnology are the heart of this mechanism type. The primary applications of passive nanostructures are in components (e.g. wires, particles, nano tubes etc.) with enhanced properties and functions due to their nanostructure [2]

Example: Colloids, Aerosols, nano particle reinforced composites, nano structured metals, surface nano patterning Polymers and ceramics.

ii) Second Generation: It refers to active nanostructures.

A nanostructure that changes its state during its operation (e.g. An Actuator changing its dimensions). The new state may act as subject to other successive changes in the electronic, mechanical, magnetic, photonics or biological properties and other effects [3]

Examples: 3D Transistors, The Amplifiers, Actuators and adaptive structures.

iii) Third Generation: It is called system of nano systems.

This cluster use various syntheses and assembling techniques (guided assembly) such as bio-assembling, networking at the nanoscale and multi-scale and hierarchical architectures, robotics on surfaces, modular nano systems, Mechano-Chemical processing of molecular assemblies, and quantum-based nanoscale systems [4]

Example: Robotics Guided Assembling, 3D Networking and new Hierarchical Architectures.

*iv) Fourth Generation***:** It is called molecular nanosystems. Molecular nanosystems are the next generation of materials and components in which each individual molecule has a specific structure that plays its own role, behaving much like biological systems. [5]

Examples: modular transistors, human machine interfaces and other neuromorphic systems.

THE FUTURE

The Fourth generation of nanotechnology basicallydeals with the manufacturing and development of nano-computer. The computer on chip and other such terms are being used for this coming technology. Here the main focus is to make computer more versatile, more powerful and the computer will be capable of doing lot more tasks than now, still it will have a very small size and have limited power consumption.

III. HOW NANOTECHNOLOGY WORKS?

Nanotechnology works on the basic principle that at nano scale properties of matter changes drastically and this small size is achieved by basic technique of 'nanofabrication'. The term Nanofabricationmeans a collection of technologies which are utilizedto make micro devices, and, the term Micro fabrication describes different process of fabrication upto micrometer size and smaller, of miniature structures. For example, the fabrication of IC (Integrated circuit).

Nanofabrication or micro fabrication technologies actually have originated from the microelectronics industry and the devices is usually made on silicon wafers. The process of Nanofabrication methods can be achieved using two different approaches: The Top down method and Bottom up method.

i) Top down Method: This method involves carving out or adding a small number of molecules to a surface. This method is generally used by electronics industry in a process called photolithography. The Photolithography is the process that transfers the geometric shape on a mask onto a silicon wafer surface by exposing it to Ultra Violet Light through lenses.

ii) Bottom up Method: This method involves creating a new structure called nano structure by creating and assembling atoms and molecules. The structure thus formed is called Nano-Structure. Nanotechnology can be used to assemble electronic components with new characteristics at atomic level, with advantages that includes potentially smaller sized with high packing density and much faster and better components can be designed.

IV. IMPACT OF NANOTECHNOLOGY ON INFORMATIONTECHNOLOGY

The immense increase in advancements and developments in nanotechnology has attracted attention of Scientist's and Engineer's community from Information Technology and from various other fields to adapt and integrate it into their technology to enhance its functionality and reduce size and also power consumption. This has propelled the current and future developments in the fields. Specifically, in IT field Nanotechnology has brought another revolution that has provided a large number of products in industry since last decade. The computers which were initially as bulky and slow are now lightening fast. The Phones which were made for only basic calling purposed are now smart enough that they cancompete with computers and have proved themselves far better than computers in various aspects.(not all but a few). This has also led in enormous research in IT.

It is believed that in near future, the IT industry will use the above technology extensively to fabricate microprocessor chips for their computing and communication devices. These chips would help build smaller, faster, reliable, efficient and lighter computers.

V. CURRENT RESEARCH & DEVELOPMENT OF NANOTECHNOLOGY ENVISIONED FOR FUTURE INFORMATION TECHNOLOGY

An Information Technology system consists of majorly three components. These three components are under consideration for shaping new Information Technology world. Here we present a deeper insight of futuristic developments going on in the field of Information technology that will play a vital role in shaping future IT world.

The future IT components which are under major developments for bringing out the change are:

*1. Computer:*A replacement of current computers with more advanced and fast processing quantum computer technology.

This will be the most advanced technology that will be responsible for replacing the current computer with the new ones.

It will have the following components:

i) Quantum Dots: Quantum dots are crystals that emit only one wavelength of light when the electrons are excited. It is a new material which is made by using bottom up method ofnanofabrication. In future quantum dots could be used as quantum bits and to form the basis of quantumcomputers.

ii) Quantum Computers: In quantum computers, the binary rates in conventional computers are repeated by quantum bitsor qubits, which can be in a state of 0, 1 andsuperposition (simultaneously both 0 and 1). As Quantum Computer are capable to hold multiple states simultaneously, it is assumed that it can perform a millions of computation at the same time. Thiswould make the computer much faster than ever before. The development of quantum computer is stillunder research.

2. Communication (Data Processing and Transmission): In the field of data processing and transmission, the development of electronic, optoelectronic and optical components is expected to leads to manufacturing of new low cost and precise process communication devices.

The development of nanoscale logical and storage components will be made from currently dominant CMOS technology using quantum dots and carbon nanotubes. The Photonic crystals will be potentially used for designing purely optical circuits as a basis for future information processing based on light only.

It will have the following components:

i) Quantum Mirage: The term quantum mirage refers to a phenomenon that may make it possible to transfer data without using conventional electrical wiring. Instead, it will force charge carriers through solid conductors, electron wave phenomena will be used to produce effective currents.

All moving particles will have a wave like nature. This is hardly of significance in everyday tasks, but in atomic dimensions, where distance is measured in nm's, moving particles may behave like waves. This is phenomenon which makes the electron microscope workable. This is of interest for researchers in nanotechnology, who are looking for ways to deliver electric currents without conventional wiring.

ii) DNA Computing: The DNAis a biological term which stands for Deoxyribo Nucleic Acid (DNA) and it carries genetic operation for the biological development of life.

It is an approach for designing nanocomputers. DNA computing uses bottom up approach to make DNA molecules and DNA logic gates.

3. Hardware (Memory and other things): The use of nanomaterials to create smaller, faster, more efficient memory for use in computers.

Here a huge research is going on to develop new, fast and efficient memory devices that can store a huge amount of data in very small size of device.

This includes:

i) Memristors: Memristors are two terminal non-volatile memory devices based on resistance switching that can be switched from a low resistance state to a high-resistance state by applying a short voltage pulse, or short current pulse.[6]Memristors are nonlinear electronic devices and they will be used in computer data storage. They have existed for years; however, the development of nanoscalememristors is a fairly recent development.[7]

Memristors are able to keep memory states, and data, in power-off modes. This being on the nanoscale is significant because it will not require poser to maintain the memory state.

ii) Phase Change Memories: A memory that relies on programmable resistances, along with scalable current and thermal mechanisms. PCM provides nonvolatile storage, which is expected to increase main memory density and capacity.[8]

Nanotechnology by virtue of its smallness as compared to existing technology will create larger storage capacity than that exists today. Phase change memory equipped devices will also likely increase the storage capacity of mobile devices as well.

iii) Graphene Transistors: The heart of the computer is the microprocessor, which is composed of several millions of transistors. These transistors form an integrated circuit (IC). The IC in various combinations and configurations allow the computer to conduct various operations. Since start of nano technology research and development, transistors has been composed silicon, germanium, and gallium arsenide.

Researches in Nano technology has resulted in development of the graphene transistors which are made up of carbon atoms bound together in a network of repeating hexagons within a single plane just one atom thick. Graphene transistors can be constructed with a single transistor being of the size of a molecule. This would allow for more transistors to be placed for instance in a microprocessor. Many important properties of graphene transistors that make them attractive are their self-cooling ability and their ability to work with minimum noise; as compared to silicon components will make then a perfect and essential component of future computers. [9]

VI. FUTURE DEVELOPMENTS

Nanotechnology is the next industrial revolution and the Information Technology industry will be radically transformed by this in future. Nanotechnology has revolutionized the telecommunications, computing, and networking industries. The futuristic 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.

VII. CONCLUSION

The paper has outlined a detailed description of nanotechnology starting from its birth to the future and how it is going to change world through its innovative technological development in the Computer Science and Information technology field. We have also seen that how Nano Technology is changing the computing we do and the Information Technology industry and putting a strong impact on future development. We have given details of numerous ongoing researches in the field and coming technologies like DNA computing and Quantum Computers. This paper thus concludes that the Nano Technology is a field that has a very great impact on the growing Computing Industry and it will surely able to make over the current industry practices and trends into new through its innovative development that will provide low cost, high power, more efficient future technologies.

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