Global Journal of Researches in Engineering
General Engineering
Volume 12 Issue 4 Version 1.0 Year 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Nanotechnology and Its Impact on Modern Computer

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Abstract - Actually 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. In this paper, we explore the development and advancement of nanotechnology which provides ample opportunity to develop a smaller, faster and reliable computer. In this paper, we are mainly concerned with top down approach and bottom up fabrication approach of nanotechnology that directly affects modern computer design and architecture.

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GJRE-J Classification : *FOR Code : 291804*

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I. Introduction

The extensive use of computer and its wide application in the modern world have forced the researchers to improve and manufacture a smaller, faster and a more reliable computer. This objective can be fulfilled by nanotechnology. Using nanotechnology we can design and manufacture electronic components and devices that can be used directly to make smaller, faster and reliable computer. According to M.C. Roco, the third and fourth generation of nanotechnology would rely heavily on research in computer science. Now, let us try to understand the meaning of nanotechnology and its implication.

II. Definition

Nanotechnology : It is defined as the engineering of functional systems at the molecular scale.

OR

Nanotechnology refers to the manipulation of matter on an atomic and molecular scale.

OR

The term nanotechnology is defined as "the design, characterization, production and application of structures, devices and systems by controlled manipulation of size and shape at the nanometre scale (atomic, molecular and macromolecular scale) that produces structures, devices and systems with at least one novel/superior characteristic or property".

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III. Man Behind Nanotechnology

K. Eric Drexler has coined or popularised or propounded the term "nanotechnology" in the 1980's.

IV. Objective of Nanotechnology

To built machines on the scale of molecules. Basically, nanotechnology works with materials, devices and other structures with at least one dimension sized from 1 to 100 nanometres. Examples are: a few nanometres wide--motor, robot arms, small electronic components, novel semiconductor devices and even whole computer far smaller than a cell.

V. Generations Of Nanotechnology

Nanotechnology has witnessed four generations till date.

a) First generation of nanotechnology

It is called passive nanostructures. Some applications are: Dispersed and contact nanostructures. Example Aerosols, colloids, coatings, nanoparticle reinforced composites, nano structured metals, polymers and ceramics.

b) Second generation of nanotechnology

It refers to active nanostructures. Some applications are: Bio- active, health effects, physico-chemical active (e.g--- 3D transistors, amplifiers, actuators, adaptive structures).

c) Third generation of nanotechnology

It is called systems of nanosystems. Some applications are: robotics, guided assembling: 3D networking and new hierarchical architectures.

d) Fourth generation of nanotechnology

It is called molecular nanosystems. Some applications are: molecular devices by design, atomic design and emerging functions.

Fourth generation of nanotechnology basically deals with the manufacturing and development of nano computer.

VI. Applications Of Nanotechnology

- *Medicine* (Diagnostic, Drug delivery, tissue engineering)
- *Cryonics*
- *Environment* (Filtration)

- *Energy* (Reduction of energy consumption, Increasing the efficiency of energy production, Nuclear accident clean up and waste storage)
- *Information and communication* (memory storage, novel semiconductor devices, novel optoelectronic devices, quantum computers)
- *Heavy industry* (aerospace, catalysis, construction)
- *Consumer goods* (Food, nanofoods, household, optics, textiles, cosmetics, agriculture and sports)

Despite, many important applications of nanotechnology, here emphasis has been given only on the area of information and communication that deals with the manufacturing and development of micro devices or electronic components required to make nano computer.

VII. Nanotechnology Techniques/Tools/Theory/Materials That Directly Affect Modern Computer

- Nanofabrication
- Quantum dots
- Carbon Nanotubes
- DNA computing
- NVRAM (non volatile RAM)
- NanoDesign (software system)

a) *Nanofabrication*

It is a collection of technologies which are utilised in making micro devices. Micro fabrication is the term that describes processes of fabrication of miniature structures, of micrometer sizes and smaller. For instance, fabrication of IC (Integrated circuit).Nanofabrication or micro fabrication technologies originate from the microelectronics industry and the devices is usually made on silicon wafers. Nanofabrication methods can be divided into two categories: a) top down methods and b) bottom up methods

- **Top down method:** It involve 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. Photolithography is the process that transfers the geometric shape on a mask to the surface of a silicon wafer by exposure to UV (ultra violet) light through lenses.
- **Bottom up method:** This method is used to assemble atoms or molecules into nanostructures.

In near future, the computer industry will use the above technology extensively to fabricate microprocessor chips. The microprocessor chips would be smaller, faster, reliable, efficient and lighter computers.

b) *Quantum dots*

Quantum dots are crystals that emit only one wavelength of light when the electrons are excited. It is a new material made by bottom up method of nanofabrication. In future quantum dots could be used as quantum bits and to form the basis of quantum computers.

i. *Working of quantum computers*

In quantum computers, the binary rate in conventional computers are repeated by quantum bits or qubits, which can be in a state of 0, 1 and superposition (simultaneously both 0 and 1). As the quantum computer can hold multiple states simultaneously, it is assumed that it has the potential to perform a million computations at the same time. This would make the computer much more faster than before. The development of quantum computer is still under research.

ii. *Limitations of quantum computer*

Since quantum computers are based on quantum mechanical phenomenon, which are vulnerable to the effects of noise, coherence disappearance and loss of quantum bits. These problems are discussed below.

- **Problem of coherence disappearance:** A quantum computer can only function if the information exists for long enough to be processed. The researchers have discovered that the coherence spontaneously disappears over the course of time. This could lead to a considerable problem for the development of a quantum computer.
- **Simultaneous existence of two states:** In a quantum computer a superconducting quantum bits can simultaneously exist in two states. Normally one of the two states disappears as soon as the system comes into contact with the outside world. The coherence then disappears as a result of the decoherence process and the information in a quantum bit is lost.

iii. *Solution to the above problem*

More research needed. There is a need to clarify the issue that molecular dynamics simulations carried out at finite temperatures of machines of some degree of complexity, in which both the mechanism itself and its mounting are subject to thermal noise.

c) *Carbon nanotubes*

It is a tube shaped carbon material that is measured in nanometre scales. With the advancement of nanofabrication technique, researchers used this material to create electronic components like transistors, diodes, relays and logic gates. These electronic components can be directly applied in making advanced computer.

d) *DNA computing*

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

i. *Major Events*

- In 1994, L. Adleman has tried to solve a complex travelling salesman problem by using DNA computing technique.
- In 1997, researchers at the University of Rochester built DNA logic gates. This development is considered as a step towards a DNA computer.
- Researchers have found that a DNA molecule can store more information than any conventional memory chip and DNA can be used to perform parallel computations.

The above developments make the idea of DNA computing very appealing to the current researchers and scientists of the world.

Note: DNA : It is a biological term. It stands for Deoxyribonucleic acid (DNA) and it carries genetic operation for the biological development of life.

e) NVRAM (non volatile RAM)

Argonne research has developed a NVRAM (non volatile RAM) made up of tiny nano engineered ferroelectric crystals. Since the tiny nano engineered ferroelectric crystals do not revert spontaneously, RAM made with them would not be erased should there be a power failure. 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.

f) Nanodesign (software system)

A research group at NASA has been developing a software system called Nano Design, for investigating fullerene nanotechnology and designing molecular machines. The software architecture of Nanodesign is designed to support and enable their group to develop complex simulated molecular machines. The main purpose behind developing this software system is design and simulation of materials based on nanotechnology.

VIII. Conclusion

The paper has outlined the definition and its wide application in brief. This paper is intended to describe the role of nanotechnology in the development of a sophisticated small computer. Also, the paper is intended to describe the dependency of particular section or field of nanotechnology which are directly related to the development of an advance computer in future.

Acknowledgement

I would like to express my deep gratitude to the vast intellectual community of the world who convey their modern scientific ideas/new theory and description of new invention and discoveries in various disciplines of study through internet. These are rich source of information and greatly support research activities. At last I would like to thank the great almighty who has given wisdom, strength and knowledge to visualise and explore things from grass root level and put on papers for the benefit of mankind and promote safe invention and new discoveries.

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