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Future of Wireless Mobile Communication with Nanotechnology and Application of CNT in MOSFETs (Nano Transistors)

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Abstract - *Nanotechnology current days has become the most recent studies of advancement and an influential research in many fields of engineering and experiments of civil, chemical, electronics, and medicine, also in material sciences. In modern century, Nanotechnology had brought renaissance in different industries which may provide more possibilities to our expectations in many fields. In electronics engineering Nanotechnology could provide good solutions for power savings, computing, sensors, memory expansion, and machine to biological interaction. Nanotechnology in research and development (R&D) field also provides ability to fabricate IC chips and sensors that are considerably smaller in size, faster, less energy consuming, and cheaper to produce than their conventional modules. In this paper we look at many issues related to Nanotechnology in communication engineering, and also provides a brief ideas of different and effective applications of various technological developments in Nano and the space for future advancements and possibilities that may lead to improved mobile and wireless communication systems. Carbon Nano Tube (CNT) is one of the prime element in Nanotechnology that have revolutionized the Nano Science field due to its extreme structural durability, strength, elasticity than other elements and smallest diameter is used in many solid state short channel devices to enhance the conductivity properties while keeping the input & output device parameters unchanged.*

Key Words: Nanotechnology, Molecular Nanotechnology (MNT), Nano transistors, Nano communication systems, Nano-machines, Nano-communications…

1. INTRODUCTION

Coming future generations of communication systems are expected to be built in Nanotechnology based devices, especially in electronics fields and computer science. In non-stationary communication systems the application of Nano science is used to make the dimensions of system confined to a Nano meter scale which will be in Nano scale range up to 100 nm. Nanotechnology also called as Molecular Nano Technology (MNT), represents Atomic and molecular based control of the structure of matter. The result of mobile and core network combined together operate in the mode of the Nanotechnology as well as high scale in security and the advance effect on the sensor makes the Nanotechnology the most implicit and better technology in these areas. Carbon Nano Tube (CNT) is one of the prime element in Nanotechnology that have revolutionized the Nano Science field due to its extreme structural durability, strength than other elements and smallest diameter [1].

One issue in Nanotechnology based communication system is availability of new and new materials on the Nanometer length scale are expected to find an important role in future issues in the field of communication devices weather mobile, wireless or wired. In such in devices having ultra-high-speed for long and short range communication, energy efficient computing devices, high bandwidth systems, higher density memory, and ultra-fast transfer protocols and connectivity. Also the use of molecules, instead of electromagnetic or acoustic waves such as in CNTs, to modulate and transmit the information incepts a new communication era that will require advanced solution systems such as molecular transceivers, channel mediums and advanced protocols for Nano networks [2].

Molecular transceivers will be easy to accommodate and operate with Nano-devices due to their small size and methods of working. These transmitters and receivers are able to read the specific molecules and to emit others as a response after processing the fed data. Recent advancements in molecular and carbon electronics have formulated new generation of electronic Nano-components such as Nano batteries, logical circuitry, Nano-tubes, Nano solid state devices in the Nanoscale and even Nano-antennas for wireless operations [3].

This paper reviews some of the applications of Nanotechnology in communication, medical engineering and also provides a review future technologies in field of telecommunication based on Nanotechnology.

2. ROLE OF NANOTECHNOLGY

Nano means very tiny or dimensions of things around 10^{-9} meters. Nanotechnology concept first developed around 1959 by Richard Faynman. It includes the processing, separation, consolidation, and deformation of materials at one atomic or at one molecule range. Fabrication of Nano devices in a scale ranging from 1 to 100 Nanometers or 10^{-9} meters. With the invention and utilization of Carbon Nano Tube material, Nano tech has been realized in vast experiments and invention of new strong and ultra-fast speed electronic solid state devices. Nano science field can

be divided into three broad categories viz, Nanostructures, Nano fabrics and Nano characterization with typical applications in Nano electronics, biological sciences and energy [4]. There are several applications of Nanotechnology nowadays one of which is that scientists can control and manipulate atoms and molecules individually. In contrast to electrical and electronics fields, a viable applications of Nanotechnology are in; Communications, Bio-engineering and Medical Electronics With the advent of Nanotechnology manufacturers are able to produce tiny, super speedy, more energy efficient, and cheap Integrated Circuit chips using ULSI technology, there are 25,400,000 Nanometers in an inch. Nanorobotics is the current emerging technological field of creating mechanical versions of human body parts or an entire robot whose components are almost invisible to naked eye. Nanorobotics refers to the Nanotechnology engineering discipline of designing and building Nano robots, with devices ranging in size from 0.1-10 micrometers and constructed of Nanoscale or molecular components [5].

In communication, though analog or digital, a mobile devices with large degree of information processing and communication when interacting with other nonliving environment such as house, office, public place etc., require an intelligent way to sense, calculate, process and communicate with each other when these devices are embedded together. Basic level requirements for this kind of mobile device intelligence is that the devices must be autonomous and robust, can be deployed easily, and survive without explicit management or care, and the mobility of these devices also implies limited smaller size and restrictions on too much power consumption and producing lowest losses at extreme high or low frequencies. Other requirements for intelligent mobile systems are; Intelligent interfacing and interacting with other devices and environments, sensing, context, awareness, and increased data rates which require more memory and computing power [6]. All these requirements lead to a situation which cannot be resolved with current existing technologies. Hence we need more sophisticated, intelligent and less error prone solutions for sensing, actuation, radio, embedding intelligence into the environment, power efficient computing and memory expansion

3. NANOTECHNOLOGY APPLICATONS

Nanotechnology plays an important role in field of electronics, communication, biomedical and photonics engineering, and make a great revolution in many aspects that deal with communication technologies wired or wireless.

3.1 Wireless technology

The telecommunication fields will tremendously get changed into the brand new Communication Nanotechnology. Nanotechnology will have a great effect in operation of both cellular as well as core wired network and by addition of advances in security and the better impact on the sensor workings combines with ultrafast speeds makes the Nanotechnology the dominant than the previous traditional technologies [7].

With the advent of micro systems and Nano technology concepts in the mobile devices will revolutionize the hand held devices viz cellular phones, computer systems, communication devices that can create a brand new platform data transmission and computing. Such Nano devices can be modified to achieve some capabilities like self-empowering, sensible to the environment variations and smart interaction with other electric or mechanical systems. The Cellular phones will be enhanced with the carbon Nanotube which comes below the Nanotechnology [8]. In five generation of mobile systems, cell phones are referred as Nano devices as they are equipped up with 700nm Nanotechnology fabricated circuit boards.

3.2 Nano transistors (Nano MOSFETs)

Nano materials have been developed along with the concept of Nanotechnology. These materials area type of separate world at Nano meter range which have their own physical, chemical properties, structures etc. one of the dominant Nanomaterial is Carbon Nano Tube (CNT). It is a tube like structure, for example a straw (hence the name), through which the electrons or molecules travel exactly as if they are travelling through empty space which results in almost no resistance, unlike in transmission lines, there is no or negligible probability of collision between the charges or carriers. It has been considered so due to its extreme physical properties which are;

1) Tensile strength: 100 times stronger than steel.
2) Conductivity: almost behaves as a superconductor (ideal). Many times larger than metals.
3) Physical dimensions: thinner than a hair follicle.
4) Resistance inside the CNT is only provided by air molecules.
5) Very high amount of elasticity.

Transistor (MOSFET or BJT or SCR) is a solid state device that has been made as the backbone of all devices that we see around us. Transistors are used in many applications to control the output of a system, amplification of a signal, switching purposes etc. With the advent of the VLSI technology scientists could fabricate hundreds of MOSFETs on a single 1 square inch silicon chip that resulted in energy savings, less space occupier devices, easy fabrication and installment etc. [8]. Now a day's 600nm fabrication technology is used in latest smart phone manufacture. More reduction in dimensions of solid state devices will lead to short channel effects. Short channel devices are those which have channel length (as in MOSFETs) smaller than the width of depletion region (<<<1 micrometer) resulting in the

overlap of depletion regions between the drain and source. As the depletion region between a PN junction is depleted of majority charge carriers, therefore no formation of channel occurs between drain and source for conduction of current known as drain current I_d.

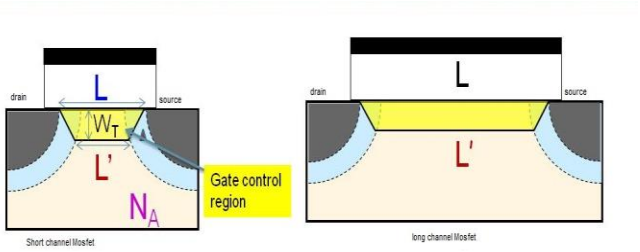

Fig -1: Short and long channel effects of MOSFET

A carbon Nano Tube is a material that behaves as a straw to allow passage of charge carriers from one side to another without interference with material surrounding it. Electrons within the tube remain isolated from external effects and can travel at much greater speeds, as mentioned earlier. Substitution of substrate formed channel inside the MOSFET with a CNT can greatly reduce the short channel effects viz hot electrons, impact ionization, resistance due to substrate on the operation of transistor, propagation delay and response time of the device, also provide very high conductivity and electrical emission.

3. 3 Nano communication and networks

Communication using electromagnetic waves of any frequency is the most basic strategy to interconnect microelectronic devices and transfer information. These waves propagate with some losses through transmission lines or over the air (OTA) [9]. To establish a bidirectional wireless Nano communication, a RF systems should be integrated in the Nano machine to coordinate which requires a Nano scale antenna system Nano DSP for reception of very high frequencies. As the height of antenna must be proportional to the 4th part of the wavelength.

$$h = \frac{\lambda}{4}$$

Where 'h' is height of antenna and 'λ' is the wavelength of EM wave.

The communication between any of the Nano scale machines is defined by which is knows as Molecular communication where the transmission and reception of information is not through the EM waves but is encoded in Nano molecules or atoms. Molecular communication cannot interconnect bigger micro devices but only the Nanometer range systems to create a Nano network [10]. Using a technique called as molecular encoding. This technique is similar to the encoding schemes of analog or digital systems where every signal is encoded (modulated) and correspondingly received and detected at the destination. Nevertheless, just like the encrypted packets in communication networks, in which only the intended receiver is capable to read the information. As shown in Figure 3 below molecular encoding is used in Nano communication, where only specific members of the transmitter specie can decode the transmitted message. Text, voice and video signals are usually transmitted over old communication networks. In comparison to Nano networks, since the message is an encoded molecule, the transmitted information is more related to phenomena of chemical processes [11].

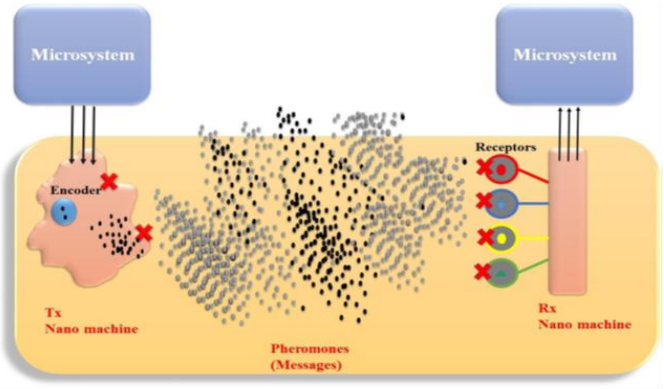

Fig -2: Molecular communication based on pheromones encoding

3. 4 Quantum computing

Newer technology replaces old ones. In traditional computers used for calculation and scientific purposes doesn't meet the requirements of speed, processing information and data sharing capabilities [12].

Replacing current computers by more improved and quick preparing quantum computers innovation, the most exceptional evolvement that will be in charge of adding better features and means of processing and computing in an intelligent way. In quantum computers, the binary rates in conventional computers are repeated by quantum bitsor qubits, which can be of the state of digits that is, 0, 1(zeros and ones) and superposition theory. The quantum computer can hold multiple states simultaneously, it is supposed that it has the potential to perform a millions of computation per second at the same time.

This would make the computer much faster than ever any scientific computer or workstation has been. The development of quantum computer is still under continuous research. With the advent of these computers in future, the world will have a newer generation of computational workstations that with have extreme speeds, data sharing efficiency, smaller space occupiers and most importantly energy consumption will be reduced to very large quantity.

3.5 Nano photonics

After decades of research it was found that the integration of electric signals with light pulses is possible. The ability to use light instead of electronic signals to transmit information within future computers and other hand held devices is called and Nano photonics. On a chip based system the silicon board is used to allow the integration of electronic and optical components side-by-side on the silicon chip using 100nm technology, this breakthrough was known as "Silicon Nano Photonics".

Silicon Nano photonics takes advantage of light pulses for communication and provides an express highway for large volumes of data to move at rapidly very high speeds between computer chips in servers, large datacenters, servers and supercomputers, thus eliminating the limitations of congestion in large data traffic, low channel capacity cables and OFCs and high-cost traditional interconnect systems and networks [13]. The huge load of data being created and transmitted over and within an enterprise network continues to grow due to an explosion and innovation of new applications and services by different industries. Nano photonics can now enable different companies to store, transmit and process bulk data, big data in real time within fractions of microseconds without loss of information and considerably reducing the propagation time. Solid state devices based on Nano photonics, it has been seen to exceed the data rates of 25 GB per channel.

4. FUTURE USING NANOTECH

Integrated circuit chips based on Nanotech or ULSI will prove to be drastic development in many fields such as Telecommunications, Bio Engineering, Medical Electronics, environmental friendly and Robotics. These fields are the fundamental locale that there is potential to offer business opportunities later on and will provide better and economic benefits to people around world [14]. In communication and information exchange, with the use of the nanotechnology will recognize new estimates of unbelievable ways to offer smart transmission mediums which can be easy to formulate and maintain. In bio medical engineering, medicines, devices and probes that are implanted within human body such as pace makers, defibrillators, and heart stents to prolong human life and reduce the risk of heart failures and damages, constantly maintaining the blood pressure, level of glucose in the blood. We could go further by implanting or injecting tiny sensors inside our bodies to deeply and delicately analyze a patient without much hassle and produce better and accurate test results. With nanotech, such foreign bodies can be fabricated at Nano meter dimensions that a patient wouldn't feel them implanted [15]. With revolutionized telecommunication systems, other aspects can be achieved such as revolution in computing and networking industries. The new generation innovation technologies may be in Nanomaterials with novel optical, electrical, and magnetic properties, faster and smaller memory, and processors, new science computers based on Quantum Computing for improved research of scientific or geological, archaeological purposes, advanced microscopy to study the surface of almost invisible objects that are in nanometer scale [16].

5. CONCLUSIONS

World is getting smaller and smaller with every advancement in technology, with the invention of high speed 4G video calling we can talk while watching our friends and relatives , who is thousands of miles away, live on a device platform. Nanotechnology has further reduced the size of the electronics world and is continuing to do so. Wireless communication is rapidly increasing and quickly expanding that has made millions of things possible which wired systems could never. The fundamental drivers for the utilization of nanotechnology in wireless devices and systems are superior, that bring down power utilization and minimize size of communication components.

Nano MOSFETs that has embedded CNT as channel can revolutionize the IC and switching times and amplifying devices and greatly improve the characteristics of traditional MOSFET. Resulting in the better quality of IC chip and the computing systems, mobile devices, navigation systems etc. Communication using molecules is integration physical world to interact with biological systems, nanotechnology to enable nanoscale and micro scale interactions, and computer science to process and control larger scale of information. Nanotechnology will significantly change the way of communication, exchange of data, fabrication of devices that are almost fully lossless. Ultra high speed processing of information integrated with artificial intelligence for improved accuracy, precision and durability of solid structures to withstand extreme pressure, weight and temperature. This paper has presented a review and new applications of nanotechnology in more sophisticated and deeply manner used communication, electronics and biomedical engineering techniques in present and expected to be used in a more intelligent way in future for betterment of world and people who rely on scientists and technology.

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