IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Impact Factor: 7.301

Volume 3, Issue 1, January 2023

Nanoelectronics

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Abstract: *This paper is design for the getting more idea about nano electronics. Nanoelectronics is the term used in the field of nanotechnology for electronic components and research on improvements of electronics such as display, size, and power consumption of the device for the practical use. This includes research on memory chips and surface physical modifications on the electronic devices. Nanoelectronics cover quantum mechanical properties of the hybrid material, semiconductor, single dimensional nanotubes, nanowires, and so forth. Well-developed nanoelectronics can be applied in different fields, and are especially useful for detecting disease-causing agents and disease biomarkers. As a consequence, point-of-care detection became popularized due to the involvement of nanoelectronics.*

Keywords: Nano Electronics; Spintronics; Nanometer

I. INTRODUCTION

The term nano electronics refers to the use of nanotechnology in electronic components. These components are often only a few nanometers in size. However, the tinier electronic components become, the harder they are to manufacture. Nano electronics covers a diverse set of devices and materials, with the common characteristic that they are so small that physical effects alter the materials properties on a nano scale – inter-atomic interactions and quantum mechanical properties play a significant role in the workings of these devices. At the nanoscale, new phenomena take precedence over those that hold sway in the macro-world. Quantum effects such as tunneling and atomistic disorder dominate the characteristics of these nanoscale devices. The first transistors built in 1947 were over 1 centimeter in size; the smallest working transistor today is 7 nanometers long – over 1.4 million times smaller (1 cm equals 10 million nanometers). The results of these efforts are billion-transistor processors where, once industry embraces 7 nm manufacturing techniques, 20 billion transistor-based circuits are integrated into a single chip.

- Nano electronic Devices
- Spintronics

Besides transistors, nano electronic devices play a role in data storage (memory). Here, spintronics – the study and exploitation in solid-state devices of electron spin and its associated magnetic moment, along with electric charge – is already an established technology. Read more: "Graphene spintronics - from science to technology".

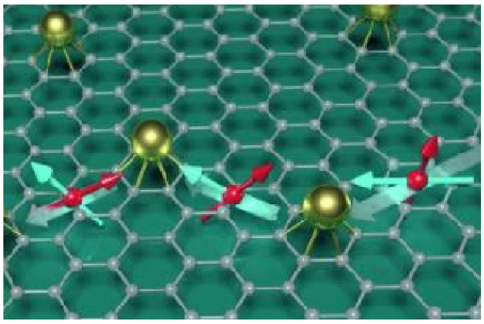

Fig 1.1 Electron spin in a Graphene lattice

Spintronics also plays a role in new technologies that exploit quantum behavior for computing (read more: "Quantum computing moves forward with spintronics progress" and "The birth of topological spintronics").

1.1 Optoelectronics

Electronic devices that source, detect and control light – i.e. optoelectronic devices – come in many shapes and forms. Highly energy-efficient (less heat generation and power consumption) optical communications are increasingly important because they have the potential to solve one of the biggest problems of our information age: energy consumption. In the field of nanotechnology, materials like nanofibers (see for instance: "Light-emitting nanofibers shine the way for optoelectronic textiles") and carbon nanotubes have been used and especially graphene has shown exciting potential for optoelectronic devices.

1.2 Displays

Display technologies can be grouped into three broad technology areas; Organic LEDs, electronic paper and other devices intended to show still images, and Field Emission Displays. For more, read our special section on Nanotechnology in Displays.

1.3 Wearable, Flexible Electronics

The age of wearable electronics is upon us as witnessed by the fast growing array of smart watches, fitness bands and other advanced, next-generation health monitoring devices such as electronic stick-on tattoos. If current research is an indicator, wearable electronics will go far beyond just very small electronic devices or wearable, flexible computers. Not only will these devices be embedded in textile substrates but an electronics device or system could ultimately become the fabric itself. Electronic textiles (e-textiles) will allow the design and production of a new generation of garments with distributed sensors and electronic functions. Such e-textiles will have the revolutionary ability to sense, act, store, emit, and move – think biomedical monitoring functions or new man-machine interfaces – while ideally leveraging an existing low-cost textile manufacturing infrastructure (see for instance "wearing single-walled carbon nanotube electronics on your skin", a "temporary tattoo to monitor glucose levels" or "graphene nanosensor tattoo on teeth monitors bacteria in your mouth").

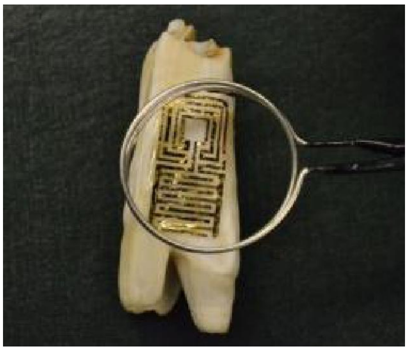

Fig 1.2 Graphene wireless sensor bio transferred onto the surface of a tooth

1.4 Nanoelectronics in Energy

Solar cells and supercapacitors are examples of areas where nanoelectronics is playing a major role in energy generation and storage. To learn more read our detailed sections on Nanotechnology in Energy and Graphene Nanotechnology in Energy.

1.5 Molecular Electronics

Distinct from nanoelectronics, where devices are scaled down to nanoscale levels, molecular electronics deals with electronic processes that occur in molecular structures such as those found in nature, from photosynthesis to signal transduction. Molecular electronics aims at the fundamental understanding of charge transport through molecules and is motivated by the vision of molecular circuits to enable miniscule, powerful and energy efficient computers (see for instance: "Adding an optoelectronic component to molecular electronics").

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1.6 Nanoelectronics Applications

With the development of microscopes in recent decades, scientists got the ability to see nano-sized materials which are as small as atoms and this had opened up a world of possibilities in a variety of industries and scientific endeavors. Designers Face hurdles for the future of Nanoelectronics. Nano-materials are miniaturization of materials. Building of machines at the molecular scale that involves the manipulation of materials on an atomic scale were about two-tenths of a nanometer is called Nanotechnology. Nanotechnology is also defined as the study of structures which are in size between 1 to 100 nanometers. Its size is eight hundred 100 nanometer particles placed side by side will be equal to the width of a human hair.

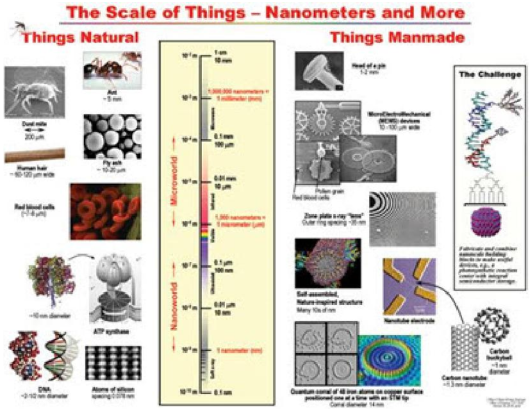

Fig 1.3 Applications of Nanoelectronics

1.7 Nanometer

As shown in the above, the chart starts with objects that can be seen by the unaided eye such as an ant and progresses to objects about a nanometer or less in size such as the ATP molecule used in humans to store energy from food.

II. NANOELECTRONICS: NANOTECHNOLOGY IN ELECTRONICS

Nanoelectronics is defined as nanotechnology which allows the integration of purely electronic devices, electronic chips and circuits. The digital systems are combined with analog/RF circuits. This type of technology fusion can be described as the 'More than Moore' domain of development. The nanoscale dimensions of nanoelectronic components for systems of giga-scale complexity measured on a chip or in a package. This scaling feature and the road to giga-scale systems can be described as the 'More Moore' domain of development.

Nanotechnology improve the capabilities of electronic components as given below-

- By reducing the size of transistors used in integrated circuits.
- Researchers are developing a type of memory chip with a projected density of one terabyte of memory per square inch and this increases the density of memory chips.
- By improving display screens on electronics devices and this reduces power consumption and also the weight and thickness of the screens.
- By traditional scaling limits in standard CMOS technology. This development of nanoelectronic components are called as 'Beyond CMOS' domain of development.

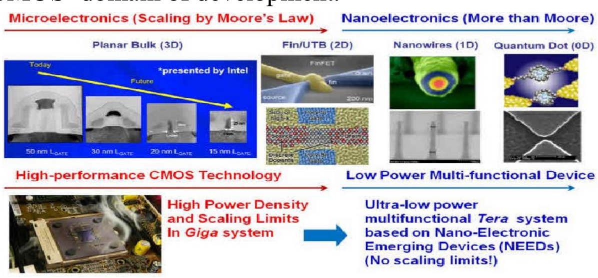

Fig 1.4 Nano Technology in electronics

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2.1 Nanotechnology in Electronics

In giga systems, when systems are designed using nanoscale components the number of components in a system may reach gigascale orders. This increases number of challenges like complexity in scaling, gigascale complexity. There is also a scaling of electrical properties such as power dissipation, supply voltage, speed, and leakage currents. Design at the architectural level is required in order to overcome problems of scaling properties. In Technology fusion, Nanotechnology makes it possible to develop new components which may be used together with electronic components in system design. Nano-sized particles of titanium dioxide and zinc oxide are used in many sunscreens to block UV radiation more effectively.

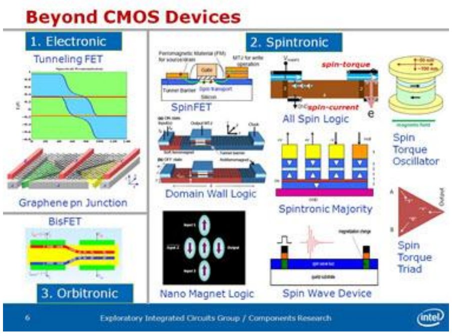

Fig 1.5 CMOS technology

2.2 Nanotechnology Beyond CMOS Devices

The phenomenal growth in the CMOS technology over the past four decades and it has high performance and storage systems. Planar CMOS technology is the main component for embedded electronic system design from several decades. It has been scaled according to Moores law resulting in ever decreasing device sizes and in a number of technology nodes, the present one being the 45nm node and in general, the scaling cannot go below approximately 10nm for MOS transistors and this limit is expected to be reached about 2015.

2.3 Transfer Characteristics Using CMOS Technology

High-performance logic circuits and Semiconductor memory had been the technology drivers to architect the miniaturization of the MOS transistor. The scaling of MOS transistor in nanoelectronics explores new materials like high-k gate dielectrics such as HfO2, Er2O3, Gd2O3; new channel materials such as germanium and grapheme and finally new device structures like double-gate FET, FinFET, Schottky source/drain FET. Clockwise from top left: a wave packet plotted on the complex plane, a model for charge injection and transport through a ballistic nanowire, a billiard ball model of a reversible computer, and the simplified energy band structure of graphene.

2.4 Nanotechnology Applications

Nanotechnology has many applications and has a variety of uses such as the ones listed below-

- Reactivity of Materials – Nanoparticles have a greater surface area per weight than larger particles and properties of some standard materials were changed when formed as nano-sized particles then they become more reactive to some other molecules.
- Nanotechnology Applications in Chemical Sensors allows the detection of a very low concentration of chemical vapors.
- Nanotechnology Applications in Space
- Nanotechnology and Water Quality – Nanoparticles can be used to convert the contaminating water through a chemical reaction to make it harmless
- Nanotechnology Applications in Sporting Goods
- Nanotechnology Applications in Batteries

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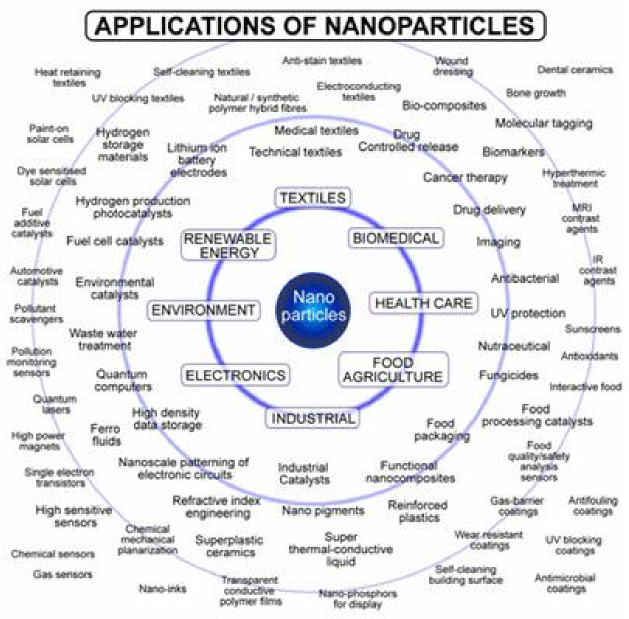

Fig 1.6 Nanotechnology Applications

2.5 Nanotechnology Applications

- Drug delivery – Most harmful side effects of treatments such as chemotherapy are a result of drug delivery methods which donot pinpoint their intended target cells accurately.
- Nanoparticles of iron can be effective in the cleanup of chemicals in groundwater because they react more efficiently to those chemicals than larger iron particles.
- Strength of Materials – Nano-sized particles of carbon like nanotubes and bucky balls are composed of only carbon and they are very strong. A T-shirt weight bullet proof vests made out of carbon nanotubes is the best example that shows how much strong will be the nanosized particles of carbon. This is because their strength comes from special characteristics of the bonds between carbon atoms.
- Nanotechnology Applications in Medicine
- Nanotechnology Applications in Electronics
- Nanotechnology Applications in Food – nanomaterials that will make a difference not only in the taste of food, but also in food safety, and the health benefits
- Nanotechnology Applications00 in Solar Cells
- Molecular Manufacturing – Star Trek replicator is a device that could produce anything from a space age guitar to a cup of Earl Grey tea. Researchers are working on developing a method called molecular manufacturing that may someday make the Star Trek replicator into reality. a molecular fabricator is a device which uses tiny manipulators to align the atoms and molecules in order to build an object.
- Nanotechnology in Fuels – production of fuels from low grade normal raw materials more efficient.
- Nanotechnology and Air Quality – can improve the performance of catalysts used to transform vapors escaping from cars or industrial process plants into harmless gases
- Nanotechnology in Fabrics – In fabrics, the clothing manufacturers were making water using nano-sized whiskers in the fabric that cause water to beat up on the surface. Fibers allow improvement of fabric properties without a significant increase in weight, thickness, or stiffness.
- Coatings and Surfaces – Coatings with thickness controlled at the nano- or atomic scale have been used in molecular beam epitaxy or metal oxide chemical vapor deposit ion for optoelectonic devices and the applications include the self-cleaning window that is coated in highly activated titanium dioxide. olymers and inorganics.

- Harder Cutting Tools – Cutting tools made of nanocrystalline materials, such as tungsten carbide, tantalum carbide and titanium carbide.

2.6 Applications of Nanoelectronics under Development

Below were the nanoelectronics applications and projects into which Researchers were looking –

- Cadmium selenide nanocrystals deposited on plastic sheets are to form flexible electronic circuits. The aim of Researchers is for low power requirements, simple fabrication process and combination of flexibility.

2.7 Applications of Nanoelectronics under Development

- Integrating silicon nanophotonics components into CMOS integrated circuits. This optical technique is intended to provide higher speed data transmission between integrated circuits than is possible with electrical signals.
- Researchers at UC Berkeley have demonstrated a low power method to use nano magnets as switches, like transistors, in electrical circuits. Their method might lead to electrical circuits with much lower power consumption than transistor based circuits.
- Silver nanoparticle ink was used to form the conductive lines needed in circuit boards. A method to print prototype circuit boards using standard inkjet printers was developed by Researchers at Georgia Tech, the University of Tokyo and Microsoft.
- Developing a lead free solder reliable enough for space missions and other high stress environments using copper nano particles.
- Functioning of integrated circuits using carbon nanotubes have been developed by Researchers at Stanford University. They had also developed methods to remove metallic nanotubes, an algorithm to deal with misaligned nanotubes.

2.8 Nano Integrated Circuits

- Laser that uses a nano patterned silicon surface that helps produce the light with much tighter frequency control developed by Researchers at Caltech.
- Nanowires that would enable flat panel displays to be flexible made from electrodes.
- Transistors built in single atom thick graphene film to enable very high speed transistors.
- Building transistors from carbon nanotubes to enable minimum transistor dimensions of a few nanometers and developing techniques to manufacture integrated circuits built with nanotube transistors.
- Researchers have developed an interesting method of forming PN junctions, a key component of transistors, in graphene.
- Combining gold nanoparticles with organic molecules to create a transistor known as a NOMFET (Nanoparticle Organic Memory Field-Effect Transistor).
- Making integrated circuits with features that can be measured in nanometers (nm)
- Using carbon nanotubes to direct electrons to illuminate pixels, resulting in a lightweight, millimeter thick "nanoemmissive" display panel.
- Using nanosized magnetic rings to make Magneto resistive Random Access Memory (MRAM).
- Researchers have developed lower power, higher density method using nanoscale magnets called magnetoelectric random access memory (MeRAM) and also developed molecular-sized transistors which increase transistor density in integrated circuits.
- Using self-aligning nanostructures to manufacture nanoscale integrated circuits.
- Using nanowires to build transistors without p-n junctions, buckyballs to build dense, low power memory devices, magnetic quantum dots, silver nanowires embedded in a polymer to make conductive layers without damaging the conductor, nanowires made of an alloy of iron and nickel to create dense memory devices.
- Memory chip that uses carbon nanotubes developed by IMEC and Nantero. This memory is known as NRAM for Nanotube-Based Nonvolatile Random Access Memory.

2.9 Future of Nanoelectronics – Electronics Without Current

- The waste heat produced by integrated circuits and consumption of power are the problems that face both laptop users and high-performance data centers.
- The researchers are exploring new way for designing and making logic circuits by integrating photosensitive organic molecules into tiny particles of semiconductor material called quantum dots.
- Researchers at the Optoelectronics Research Centre (ORC) of TUT are developing a technology platform for the logic circuit made up of quantum dots.
- Researchers at Tampere University of Technology have launched a cross-disciplinary project entitled "PhotonicQCA" that combines expertise in organic chemistry, semiconductor growth and nanofabrication.
- Current is simply the flow of electrons in a particular direction. This new type of logic circuit consumes no current because the movement occurs when a single electron travels from one quantum dot to another.

III. FUTURE OF NANOELECTRONICS

- Researchers at the Department of Chemistry and Bioengineering are looking into ways of bridging the gap between nanoscale and macroscale. Researchers at the Department of Electronics bring their expertise in novel architectures to the project.
- The form of carbon called a "nanotube" is one of the earliest forms of nanotechnology.
- Nanostructures could serve as new kinds of drugs for treating common conditions such as cancer.
- Nano-engineered solar panels produce more energy.
- Nanotech batteries last longer, lighter and more powerful.
- Dangerous side effects of current treatments like chemotherapy.
- Novel Parkinson's, and cardiovascular disease, or as artificial tissues for replacing diseased kidneys and livers.

Thus, the nanoscale is the scale of atoms and molecules, the fundamental building blocks of the material world and future applications will increase including treating cancer, generating renewable energy and providing clean water anytime, anyplace. The greatest challenge to benefiting from nanotechnology is having the foresight to develop and use it wisely.

REFERENCES

[1]. Nanoelectronics | List of High Impact Articles | PPts | Journals | Videos (scitechnol.com)
[2]. Nanoelectronics: Materials, Devices, Applications Dr. Dr. h.c. Marcel Van de Voorde Professor,, Robert Puers Professor,, Dr. Livio Baldi, Dr. Sebastiaan E van Nooten
[3]. Introduction to nanoelectronics Book by V. V. Mitin
[4]. The Future if Nanoelectronics & How Scientists Design Them To Address Global Needs | Science Times
[5]. Nanoelectronics for Next-Generation Integrated Circuits bdited By Rohit Dhiman