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Role of Nano Electronics in Modern Era

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ABSTRACT
We know that the nanoscale electronic devices are of great interest for all kinds of applications like switching, energy conversion and sensing. The objective of this paper, however, is not to discuss specific devices or applications. Rather it is to convey the conceptual framework that has emerged over the last twenty years, which is important not only because of the practical insights it provides into the design of nanoscale devices, but also because of the conceptual insights it affords regarding the meaning of resistance and the essence of all non-equilibrium phenomena in general. We present a unified description applicable to a wide variety of nanodevices from molecular conductors to carbon nanotubes to silicon transistors covering transport regimes.
Keywords: Nano devices, nanoscale ,nano resistor, inductor and capacitor

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I. INTRODUCTION

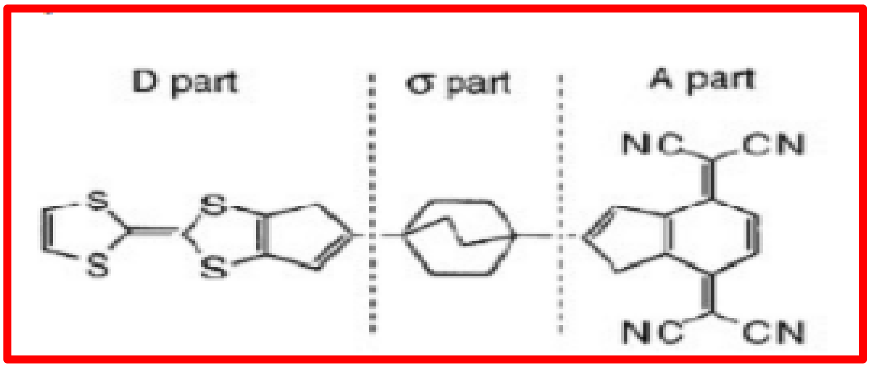
What is Nanotechnology?

Definition: The word Nano means very small and the size of Nanometer that is 1nm = 10^{-9}m which is about 100,000 times smaller than the human hair. The making new things at this incredibly small scale is called nanotechnology and it is one of the most exciting and fast-moving technology in today's world. Some nanomaterials have naturally occurred that we can found in everywhere, for example in volcano ashes, in oceans, in the dust, etc. Some of the naturally occurring nanostructures are also present in plants and animals.Now a day's scientists can also create nanostructures themselves by rearranging the atoms of an object. Those objects can make new nanomaterials with new properties. These properties also change according to science and this is the magic of nanotechnology. Some of the nanoparticle manufacturer companies in India are Mittal Enterprises in Hyderabad, Nano Orbital Private limited in Hyderabad, Nano Span Private Limited, etc.

The invention of the transistor in 1947 is one of the most important inventions of the 20th century. Since its inception, we have witnessed dramatic advances in electronics that have found uses in computing, communications, automation and other applications that affect just about every aspect of our lives. To a large extent these advances have been the result of the continuous miniaturization or 'scaling' of electronic devices, particularly of silicon-based transistors, that has led to denser, faster and more power-efficient circuitry. Unfortunately, the scaling down must eventually end. Increasing power, capital costs, and ultimately theoretical size limitations, are poised to halt the process of continually shrinking the transistor. The realization of the approaching limits has inspired a worldwide effort to develop alternative device technologies. Some approaches involve moving away from traditional electron transport-based electronics: for example, the development of spinbased devices. Another approach, maintains the operating principles of the currently used devices primarily that of the field effect transistor, but replaces a key component of the device, the conducting channel, with alternate material which have superior electrical properties. Taking into consideration the second approach, inexpensive, functional and atomically precise molecules could be the basis of future electronic devices, but integrating them into circuits will require the development of new ways to control the interface between molecules and electrodes. Molecular-electronics show promise as a technology to continue the miniaturization of ICs. However, whether molecular-electronics will be a replacement for conventional ICs, or as a complimentary technology, is yet to be determined. What has already been shown is that components such as wires and molecular switches can be fabricated and integrated into architectures. It is also known that these devices will be prone to defects, fluctuations and that fault tolerance schemes will be an integral part of any architecture. The greatest progress has been made in the research of the components that may make up nanoelectronics. Researchers have been able to fabricate molecules that have two states, such that the molecules can be switched "on" and "off". Some of these molecules have shown the functionality of diodes or variable resistors. Scientists have also been able to fabricate silicon nanowires and carbon nanomaterials such as one-dimensional (1D) carbon nanotubes (CNT) or twodimensional (2D) graphene layers. Both of these technologies can be used as wires or devices, and in some cases both. Nanoimprint lithography, probably the most promising wire fabrication technique, has been used to produce working memories on the nanometer scale. While all of these devices have been demonstrated, more lot of research is required to reliably produce such analogues.

II. MOLECULAR ELECTRONICS

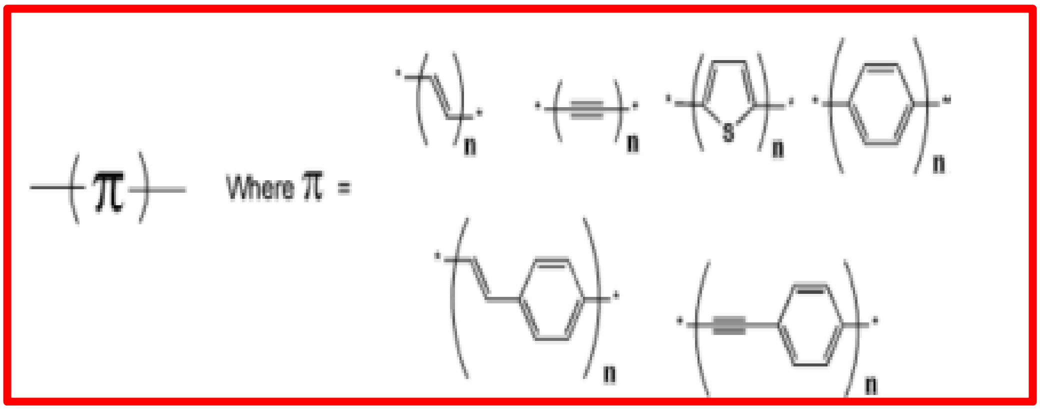
The field of molecular electronics has been around for more than 40 years, but only recently has some fundamental problems been overcome. It is now time for researchers to move beyond simple descriptions of charge transport and explore the numerous intrinsic features of molecules. Fundamentals of electronics say that all the electronic operations take place through the transport of the electron in the circuit. Robert Mulliken and Albert Szent-Gyorgi in 1940 , advanced the theory of molecular conduction and did an interesting study of charge transfer in "donor-acceptor" systems. Bringing out correlation in such donor-acceptor systems where the charge transfer can be achieved easily suggested these systems would be suitable for the molecular electronic devices. In the early 1970s, a visionary concept of exploiting the intrinsic functionality of molecules for electronics was sketched out by AriehAviram and Mark Ratner. In their pioneering theoretical work, Aviram and Ratner suggested that a single molecule (Fig.1) could function as a rectifier. The molecule would mimic a semiconductor-like band structure by taking advantage of electron-rich and electron-poor moieties to achieve one-way conduction through differently aligned molecular orbitals with respect to the Fermi energy of the electrodes . With this excellent article by Aviram-Ratner the era of molecular electronics was established



Fig(1) Proposed molecular rectifier by Aviram and Ratner [3].

2.1.Potential Organic Molecules that Mimic the Traditional Semiconductor Electronic Components: Traditional electronics has many components like conductor (wires), resistor (insulating connection), diode (rectifier), transistor (triode), logic circuits, etc. Among all these, the most fundamental components are wire, resistor and rectifier, which are discussed below. Transistor is also having equal importance in the field of electronics, but it can be easily fabricated from the diode by utilizing a suitable doping of a gate electrode.

2.1.1.Molecular Wires: Electronic wires are the components through which electric current can pass from one end to the other end freely. Organic molecules, which can mimic the wire function, are the π-type systems as shown in fig.(2).



Fig(2) Potential organic molecular wires.

In these molecules, the process of electron transfer takes place through the backbone of fully delocalized π-bridges, and consequently energetically closely spaced frontier molecular orbitals (reduced HOMO-LUMO gap or in short, HLG) are the conduction channels. Due to very small HLG, the process is thermodynamically favourable and ultimately gives rise to efficient wire function.

2.1.2.Molecular Resistor: Organic molecules to achieve resistor type of behaviour are as shown below in Fig.(3).

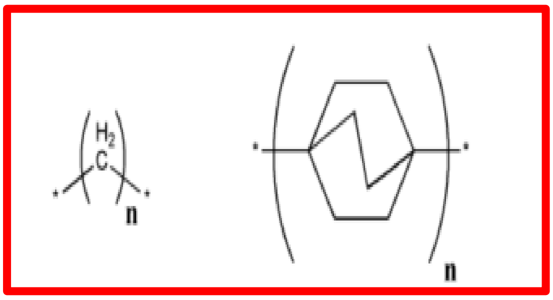
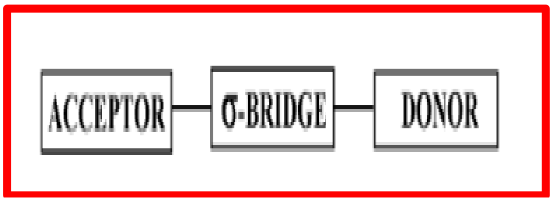


Fig.(3) Potential organic molecular resistors.

In these types of molecules, the presence of the saturated –CH2 - units creates nodes in their electron densities above the atomic nuclei. For this reason and also due to large HLG, they cannot transport electrical current. This enables aliphatic molecules or groups to act like resistors.In these types of molecules, the presence of the saturated –CH2 - units creates nodes in their electron densities above the atomic nuclei. For this reason and also due to large HLG, they cannot transport electrical current. This enables aliphatic molecules or groups to act like resistors.

2.1.3.Molecular Diodes: Starting from the AR rectifier to till date, the common construction principle of organic molecular rectifier adopted is as shown in Fig.(4). A comparison of the AR rectifier (Fig.1) with that of the semiconductor diode will give a clear idea about the rectification ability of general organic molecular rectifiers.



A structural correlation of the AR rectifier to a normal silicon junction diode shows that, acceptor part of the molecule can be mimicked with p-type semiconductor, donor part can be mimicked with n-type semiconductor and σ-bond can mimic the pn-junction barrier. With these favourable structural features of an organic molecule, it can be expected to result in similar characteristics like that of a semiconductor rectifier.

2.2. Reason for Molecules as Electronic Components: The distinguished points, which can be put in favour of molecules as electronic components are: (1) Molecules are of very small size. A molecule is around few thousand times smaller in size than that of the presently used semiconductor transistor. (2) In semiconductor devices, due to the band structure, electron can stay at any level of the band, which can probably interfere with other devices. In the molecule, the energy levels are quantized and discrete and hence the interference can be nullified. (3) Due to localizable π-systems present in the molecule, the electron transport will be thermodynamically more favourable compared to the semiconductor systems. (4) Due to the flexible nature of the molecule (especially in π-systems due to cis- &trans isomerism) switching function (on and off control) can be easily achieved by the simple alternation of the two conformations. (5) Due to exact chemical equivalence of the molecules, it can be fabricated in a defect free fashion. (6) Another important property of organic molecules is its self-assembling nature, which will be helpful in manufacturing large arrays of identical devices.

2.3.Recognizing the Components of the Molecules in the Circuit: There are some fundamental questions which can arise in one's mind that how molecules can be interleaved in an electronic circuit. The various widely used methods (for inserting a molecule in an electroniccircuit) include scanning tunneling microscopy (STM), conducting atomic force microscopy (AFM), break junctions, fixed-gap nanojunctions, nanopores, mercury drop contacts and crosswire assemblies. All the methods discussed above have their advantages, but the major difficulty in all this is counting the number of contacts molecules and the characterization of their bonding patterns. "Tour-de-force assembly mechanism" for interleaving a molecule into circuit is one such outstanding method. For a better understanding of the circuital operation of the inserted molecule into the nano-junction, a schematic diagram is shown in Fig.(5).

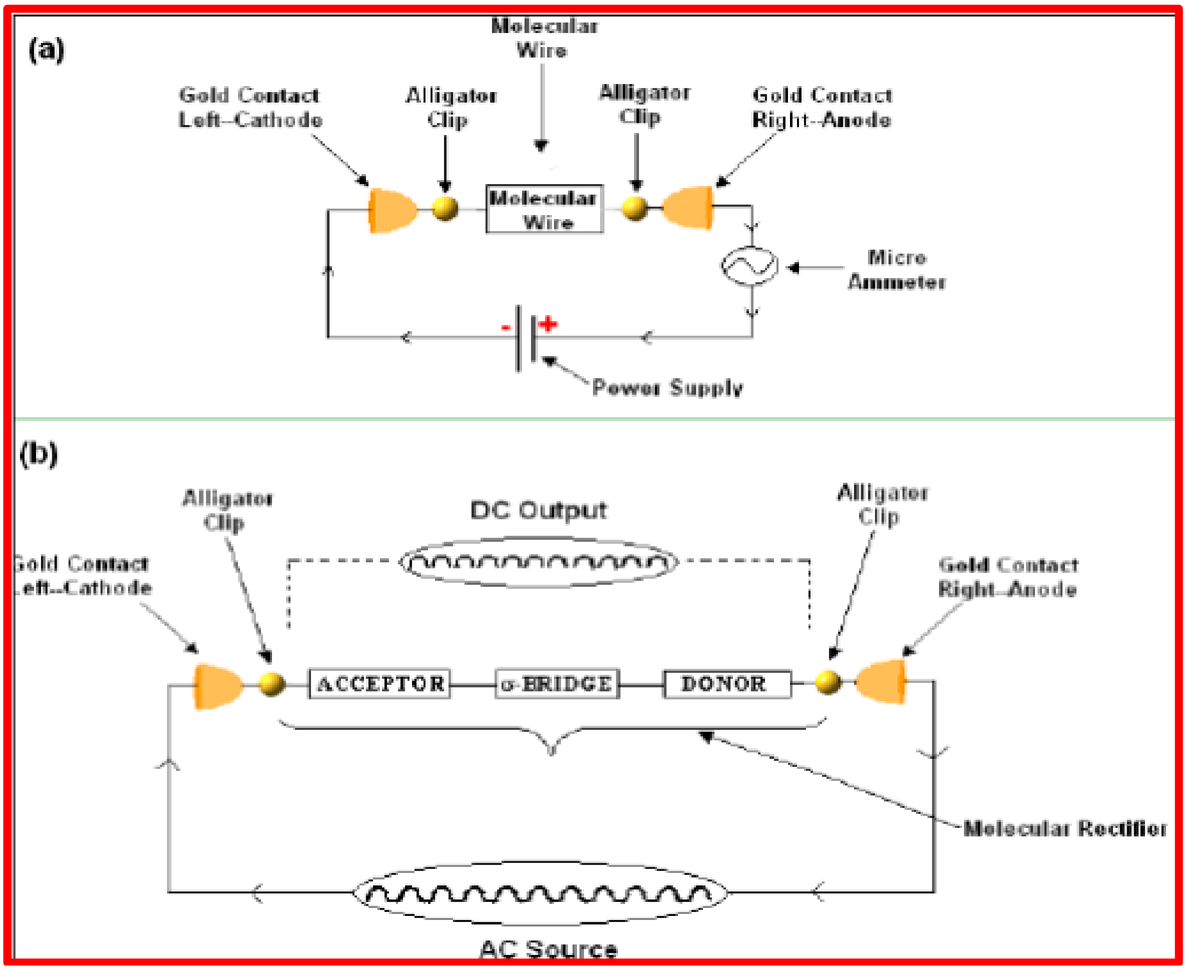


Fig.(5) Schematic representation of the circuital operation of an organic (a) Molecular wire, and (b) Molecular rectifier

Though the actual measurement process is not so simple, the above circuit diagram presents the essential components and the background operation principles of the molecular wire or rectifier in a simpler way. The diagram shows that, besides the external power supply and the output measurement components, there are three most important components, which are essential in the device fabrication as described below:

The Molecule: Here the molecule is either the wire or the rectifier. In both the cases, the molecule is needed to be both ends selected in order to make contact with the electrodes. **Gold contacts:** There are two gold contacts; left contact is named as Cathode and right contact as Anode. These create the connection between the molecule and the external power supply.

Carbon Electronics

Apart from organic molecules, there are so many potential molecules available which can be explored for molecular electronics, e.g. Biomolecules: DNA, Proteins, and Carbon materials: Carbon nanotubes, Graphene, etc. Since biomolecules are highly unpredictable in the environmental conditions hence DNA and protein’s electron transport is necessary to understand life processes but are not sufficient for nanoelectronics. Rather, carbon materials having intriguing electrical properties can be a very good future option for nanoelectronics.

4.1.Carbon Nanotubes Based Electronics: Carbon Nanotubes (CNTs) are allotropes of carbon with cylindrical shapes and very high length to diameter ratio of the order of 1,32,000,000:1. CNTs are of hollow structure formed by rolling, one atom thick sheet of sp2 hybridized carbon atoms named as graphene. CNTs are characterized as single wall CNTs (SWCNTs) and multiwall CNTs (MWCNTs). Electronic properties of CNTs depend upon its chiral angle (angle along which graphene sheet is rolled) and radius of nanotube.

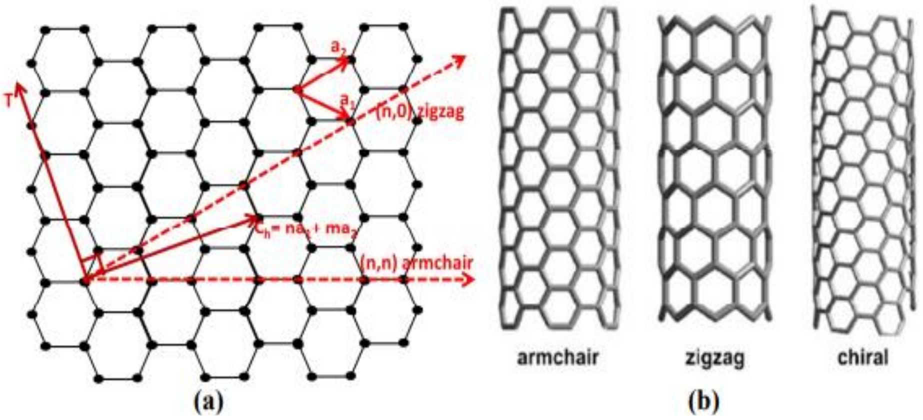


Fig.(6) (a) The (n, m) nanotube naming scheme can be thought of as a vector (Ch) in an infinite graphene sheet that describes how to "roll up" the graphene sheet to make the nanotube. T denotes the tube axis, and a1 and a2 are the unit vectors of graphene in real space, and (b) Different types of CNTs.

The structure of a SWNT can be conceptualized by wrapping planar sheet of graphene into a seamless cylinder as shown in fig. 6. The way, the graphene sheet is wrapped is represented by a pair of indices (n, m). The integers, n and m, denote the number of unit vectors along two directions in the honeycomb crystal lattice of graphene. If m = 0, the nanotubes are called zigzag nanotubes, and if n = m, the nanotubes are called armchair nanotubes. Otherwise, they are called chiral nanotubes. Diameter of ideal CNT can be calculated from its unit vector (n, m) as follows:

$$D \text{ (in pm)} = 78.3(n^2 + m^2 + nm)^{0.5}$$

All MWCNTsare of metallic in nature but nature of SWCNTs varies with chiral vectors n and m. SWCNTs are very important type of CNTs, because their properties vary significantly with chiral vectors. The band gap of SWCNTs can vary from 0 to 2eV, thus electrical properties can be metallic as well as semiconducting. A major problem in synthesis of SWCNTs is the lack of synthetic methods that yield exclusively semiconducting nanotubes, which has stimulated numerous attempts to either separate semiconducting tubes from the as-prepared material or to selectively eliminate the metallic tubes]. The separation approach has mainly depended on non-covalent chemical functionalization by various types of polymers capable of selectively wrapping semiconducting SWCNTs, most conspicuously polyfluorenes Another method based upon the selective binding of semiconducting tubes by the terminal amino groups of the silane layer on the silica has been explored for self-sorting of SWCNTs by spin-coating nanotubes from solution onto appropriately surface-functionalized Si/SiO2 substrates [22, 23]. Some other efficient chemical methods including effect of dizonium salt and plasma ion etching to eliminate metallic nanotubes are also use.

4.1.1. Carbon Nanotube Based Field Effect Transistor:

Carbon Nanotube based Field Effect Transistor (FET) Fig.(7) functions as Schottky barrier transistor rather than conventional bulk transistors. In the conventional transistors the gate bias not only affects the carrier density through conducting channel but also the transmission through junctions. Hence, both junction potential as well as carrier potential was affected by gate potential. That is why, to minimize Schottky barrier for one type of charge carrier, proper contact metal choice is needed. It was first demonstrated for palladium contacts enabling nearly barrier-free access to the valence band of semiconducting tubes. Schottkybarrier potential can be reduced by selectively doping contacts of carbon nanotubes which has been realized on the basis of complex charge transfer between CNTs and adsorbed molecules. In order to optimize the gate switching, the capacitive coupling of the gate electrode has to be enhanced. In the ideal case, the classical electrostatic capacitance Cg would become larger than the quantum capacitance C_q of the tube (C_q= 10^{-16} F/µm), and therefore, dominates the switching action.

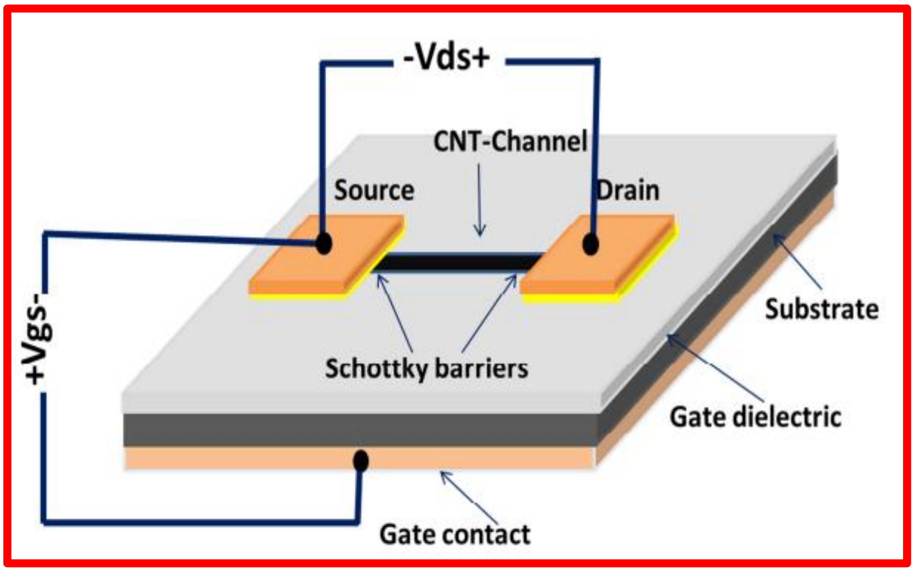


Fig. 7: CNT-FET having patterned drain and source contacts of Au/Ti over CNT.

A promising approach takes advantage of the excellent insulating capability of high-quality organic self-assembled monolayers in combination with a thin, oxygen-plasma-grown oxide layer for strong gate coupling to CNTs. It has been reported that SWCNT-FET using SiO2 with silane, showed excellent operating voltage of 1V and sub-threshold swing of 60mV per decade (A decade corresponds to a 10 times increase of the drain current Id). Significant progress has also been achieved in the development of FETs incorporating highly ordered SWCNT arrays produced via oriented CVD growth on quartz substrates. Remarkably, even without enrichment of semiconducting tubes, the transistors display excellent performance, as reflected in sub-threshold swings as low as 140mV per decade, mobility of up to 80cm2 /Vsec., and operation voltages below 5 V. A key factor to achieve this has been to reduce the probability of metallic pathways through use of sufficiently narrow network stripes. The major disadvantage of CNTs, however, is their random distribution, which clearly hampers their utilization as a replacement for silicon as a substrate. This leaves two options for carbonelectronics: either self-organization methods for CNTs or carbon “substrates”, thin layers with similar properties to CNTs. High on the list is graphene, planar sheets of honeycomb carbon rings just one atom thick. This nanomaterial supports a range of properties including ultra-strength, transparency (because of its thinness) and blisteringly fast electron conductivity—that make it promising for flexible displays and super speedy electronics.

4.2.Graphene Based Electronics: The impressive physical properties of graphene like unique optical transparency, superior mechanical strength, and excellent charge carrier mobility make it a suitable candidate for device applications which include electronics, optoelectronics, photonics, and spintronics. The most significant electrical property of graphene is due to the presence of massless, chiral, Dirac fermions which manifest as high carrier mobility of the order of 10,000 cm2 /Vs in experimental measurement and a theoretically 27,000 cm2 /Vs. Therefore it should enable transistors of very high frequency. Isolated only four years ago, graphene already appears in prototype transistors, memories and other devices. Graphene is an extremely promising material in the field of electronics. It comes majorly in two variants: Zigzag and Arm chair, depending on the edge pattern as visible in fig.(8).However, when using it as a material for transistor channel without any further improvement, the insufficient on/off ratio has been pointed out due to inadequate band gap. Nevertheless, many potential solutions to band gap formation have been proposed, such as application of the vertical electric field, forming graphene in a ribbon structure or modulating band gap with chemical functional groups.

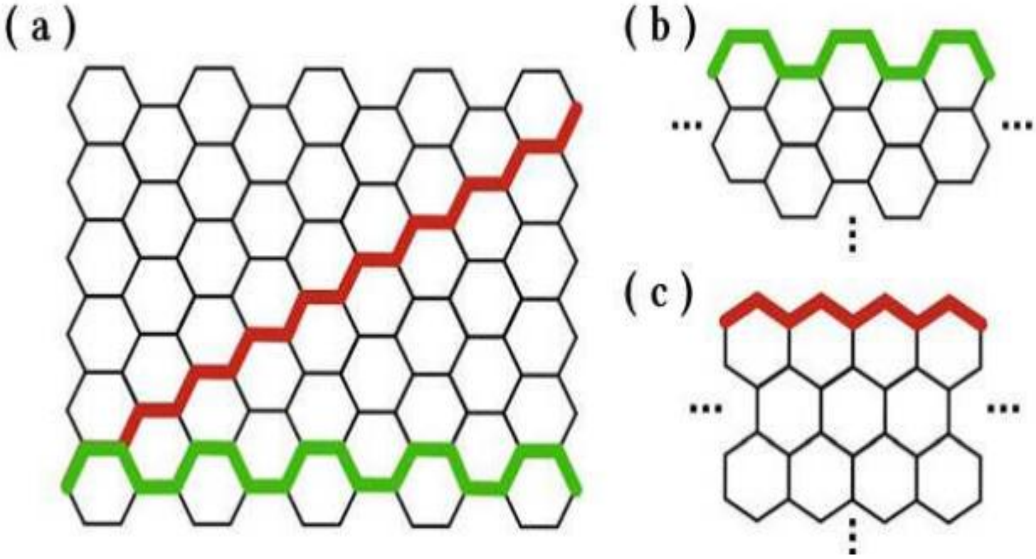


Fig.(8)(a)Graphene sheet with both the zigzag (red) and the arm chair (green) directions, (b) AGNRs, and (c) ZGNR [32].

5.Nanotechnology Applications: Advantages and Disadvantages

The father of Nanotechnology is Heinrich Rohrer. He was born on 6th June 1933 and died on 16th May 2013 in Switzerland. He is an employer in IBM and he got a Nobel prize in Physics. Some of the nanoparticles manufacturer companies are Adnano Technologies Private Limited in Majjigenahalli, Advanced Nanotech Lab in Maharashtra, Auto Fiber craft in Jharkhand, etc. The term has two parts Nano and Technology. The word Nano means a very small in size and everyone knows what a millimeter is if we cut down a millimeter into thousand equal parts one part of them is called a micrometer. If we cut the micrometer further down into thousand equal parts one part of them is called nanometer. Technology is a strategy or process developed by science for the betterment of our life. A brief explanation of nanotechnology applications is discussed below.

The applications of Nanoelectronics are shown below

Computers, Memory storage, Novel optoelectronic devices, Displays, Quantumcomputers, Radios, Energyproduction, Medical diagnostics, Nano Medicines The main aim of nanotechnology in Nanomedicine is to monitor and improve the biological systems of all human beings working from the molecular level. An Abraxane is the one type of Nanomedicine in nanotechnology. Another name of Abraxane is Paclitaxel, it is used for the treatment of breast cancer and pancreatic cancer and also in the treatment of lungs.

The advantages of Nanoelectronics are shown below Memory chips density increases,Weightdecreases,In the process of chips fabrication nanolithography is used,In integrated circuits, transistors size decreases or reduces,Electronic devices display screens improved,Power consumption reduced

Nanotechnology Applications in Nanomedicine

The Nanotechnology applications in Nanomedicine are shown below

Medicine,Heartdiseas,Drugdelivery,Diagnostictechniques,Diabetes,Kidneydisease,Woundtreatment,Anti-bacterial treatment, Cellrepair, Resources, Companydirectory, Nanomedicine Advantages

Conclusion

A variety of micromaterials and Nanomaterials have been synthesized that exhibit unique mechanical, electrical, and photonic properties, and have been used as functional elements in device applications. For example, self-assembly of silica microspheres resulted in a photonic crystal with a complete three-dimensional bandgap

[1]. Semiconductor nanowires were used to construct nanoelectronic circuits [2], solar cells [3], and nanosensors for the detection of biological and chemical species [4]. Device construction usually

requires the positioning of micro and nanomaterials. Taking one-dimensional nanomaterials as an example, nanowires/nanotubes need to be positioned between source and drain electrodes for building nanotransistors and biosensors. To position relatively large amounts of materials simultaneously, large-scale methods are used, namely, self-assembly [1], contact printing [5], and dielectrophoresis [6]. However, these methods represent probabilistic strategies and are not capable of precision control of individual materials. By contrast, mechanical manipulation, despite being slow in comparison with the aforementioned large-scale methods, promises specificity, precision, and programmed motion, and thus, can enable the precise manipulation of individual materials. For the manipulation of micromaterials, a micromanipulator under an optical microscope is used. The end-effector can be either a microprobe or a microgripper. Owing to the strong adhesion forces (capillary forces, electrostatic forces, and van der Waals forces) at the microscale, manipulation is unreliable and has low repeatability, motivating the development of suitable manipulation tools and strategies. Nanotechnology with all its challenges and opportunities will become a part of our future. The researchers are optimistic for the products based upon this technology. Nanotechnology is slowly but steadily ushering in the new industrial revolution.

REFERENCES

[1]. "MEMS Overview".Retrieved 2009-06-06.
[2]. Melosh, N.; Boukai, Abram; Diana, Frederic; Gerardot, Brian; Badolato, Antonio; Petroff, Pierre & Heath, James R. (2003). "Ultrahigh density nanowire lattices and circuits". Science 300 (5616): 112-115. Bibcode:2003 Sci...300..112M.doi:10.1126/science.1081940 . PMID 12637672.
[3]. Das, S.; Gates, A.J.; Abdu, H.A.; Rose, G.S.; Picconatto, C.A.; Ellenbogen, J.C. (2007)."Designs for Ultra-Tiny, Special-Purpose Nanoelectronic Circuits". IEEE Trans. on Circuits and Systems I 54 (11): 11. doi:10.1109/TCSI.2007.907864.
[4]. Ting Zhu, Sylvain G. Cloutier, Ilia Ivanov,Kenneth L. Knappenberger Jr., IstvanRobel, Fan Zhang, "Nanocrystals for Electronic and Optoelectronic Applications", "Journal of Nanomaterials, Volume 2012 (2012), Article ID 392742, 2 pages, http://dx.doi.org/10.1155/2012/392742.
[5]. Petty, M.C.; Bryce, M.R.; Bloor, D. (1995). An Introduction to Molecular Electronics. London: Edward Arnold. ISBN 0-19-521156-1.
[6]. Aviram, A.; Ratner, M. A. (1974). "Molecular Rectifier". Chemical Physics Letters 29 (2): 277– 283. Bibcode:1974CPL....29..277A. doi:10.1016/0009-2614(74)85031-1.
[7]. Aviram, A. (1988). "Molecules for memory, logic, and amplification". Journal of the American Chemical Society 110 (17): 5687–5692. doi:10.1021/ja00225a017.
[8]. Postma, Henk W. Ch.; Teepen, Tijs; Yao, Zhen; Grifoni, Milena; Dekker, Cees (2001)."Carbon nanotube single-electron transistors at room temperature". Science 293 (5527): 76– 79.
[9]. Bibcode:2001Sci...293...76P. doi:10.1126/science.1061797.PMID 11441175.[9].Xiang, Jie; Lu, Wei; Hu, Yongjie; Wu, Yue; Yan; Hao&Lieber, Charles M. (2006). "Ge/Si nanowire heterostructures as highperformance field-effect transistors". Nature 441 (7092): 489–493. Bibcode:2006Natur.441..489X. doi:10.1038/nature04796.PMID 16724062.
[10]. Waldner, Jean-Baptiste (2007). Nanocomputers and Swarm Intelligence. London: ISTE. p. 26.ISBN 1-84704-002-0.
[11]. Jensen, K.; Jensen, K.; Weldon, J.; Garcia, H. &Zettl A. (2007). "Nanotube Radio".NanoLett. 7 (11): 3508–3511. Bibcode:2007NanoL...7.3508J. doi:10.1021/nl0721113.PMID 17973438.
[12]. Tian, Bozhi; Zheng, Xiaolin; Kempa, Thomas J.; Fang, Ying;Yu, Nanfang; Yu, Guihua; Huang, Jinlin&Lieber, Charles M. (2007). "Coaxial silicon nanowires as solar cells and nanoelectronic power sources". Nature 449 (7164): 885–889.Bibcode:2007Natur.449..885T. doi:10.1038/nature06181. PMID 17943126.
[13]. "Power from blood could lead to 'human batteries'". Sydney Morning Herald. August 4, 2003. Retrieved 2008-10-08.
[14]. LaVan, D.A.; McGuire, Terry & Langer, Robert (2003). "Small-scale systems for in vivo drug delivery". Nat. Biotechnol. 21 (10): 1184–1191. doi:10.1038/nbt876.PMID 14520404.
[15]. Grace, D. (2008). "Special Feature: Emerging Technologies". Medical Product Manufacturing News. 12: 22–23.
[16]. Saito, S. (1997). "Carbon Nanotubes for Next-Generation Electronics Devices". Science278 (5335): 77–78. doi:10.1126/science.278.5335.77.
[17]. Cavalcanti, A.; Shirinzadeh, B.; FreitasJr, Robert A. & Hogg, Tad (2008)."Nanorobot architecture for medical target identification".

Nanotechnology 19 (1): 015103(15pp).Bibcode:2008Nanot..19a5103 C. doi:10.1088/0957-4484/19/01/015103.[18].Cheng, Mark Ming-Cheng; Cuda, Giovanni; Bunimovich, Yuri L; Gaspari, Marco; Heath, James R; Hill, Haley D; Mirkin,Chad A; Nijdam, A Jasper; Terracciano, Rosa; Thundat, Thomas & Ferrari, Mauro (2006). "Nanotechnologies for biomolecular detection and medical diagnostics". Current Opinion in Chemical Biology 10 (1): 11–19.doi:10.1016/j.cbpa.2006.01.006. PMID 16418011.

[18]. Patolsky, F.; Timko, B.P.; Yu, G.; Fang, Y.; Greytak, A.B.; Zheng, G.; Lieber, C.M. (2006). "Detection, stimulation, and inhibition of neuronal signals with high-density nanowire transistor arrays". Science 313 (5790): 1100–1104. Bibcode:2006Sci...313.1100P. doi:10.1126/science.1128640. PMID 16931757.

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