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REVIEW ARTICLE

An Overview of Recent Progresses in Nanotechnology

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ABSTRACT

Nanotechnology is one of the research fields which draw serious attention of industrialists. It deals with the methods used to study the physical events and construction of structures in the range of 1-100 nanometres (nm). Incorporation of these structures into applications also takes a part. The enormous potential to build materials with unique properties for different applications makes it an area of profound interest. The nanotechnology based products include electronics goods, sporting materials, personal care and automotive parts. However the main disadvantage is that these materials and their unique characteristics pose considerable risks to environment and human health. Understanding the scope and diversity of the industry is a vital step in identifying potential risks related with them. It is like an electronics industry toolkit that gives us tools which permit us to make nanomaterials with ultra-fine particle size and crystalline structure. The application of nanotechnology in telecommunication industry is also on the rise. The strategies speaking on include sensors, Nano scale antennae and nanotubes. The primary aim of this paper is to study the recent aspects of "nanotechnology". It also gives a brief explanation of nanotechnology and its applicability in various fields such as medicine, food technology, computing, robotics, solar cells etc. Towards the end a brief overview of emerging commercial applications of Nano electronics has been included. Risks experienced in advanced nanotechnology are also discussed.

Keywords: Nanotechnology, Nano materials, Nanotubes, Quantum dots, Nano electronics.

1. INTRODUCTION

Normally, nanotechnology deals with developing materials, structures or devices with dimensions in the range of 1 to 100 nanometers (nm). At these scales, quantum mechanical consequences become the primary concern and play a vital role in determining material characteristics and performance of the devices. Nanotechnology is considered to be a key technology for the future. It has succeeded in several research areas of scientific and technological advancements because of the advantages such as low reduction, compactness, less energy consumption, novel functionalities and unprecedented performance. It assists technologies that operate at the nanometer level (one billionth of a meter). Applications include different areas, one of them being electronics. The applicability of nanotechnology in electronics do not itself pose any threat to human health, though additional processes may result in them [1]. However, there are certain aspects of nanotechnology that possess threats to environment and human health. Such contributions are mostly given by artificially manufactured nanoparticles. In electronics industry dissimilar nanomaterials are being used for research purposes. Some of the most commonly used nanomaterials are quantum dots, carbon nanotubes and silver nanoparticles. The electronic industry already uses nanotechnology and it is a surprising fact that many of today's electronics appliances have already incorporated several applications developed by the science of nanotechnology. For example, new computer microprocessors have features in the range of 100 nanometers (nm). Smaller sizes mean rise in speed and processing capability.

These advances will undoubtedly help in attaining better computers. Though, at some

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point in time (very near in the future) present electronic technology will no longer be sufficient to handle the demand for new microprocessor chips. At present, the method of manufacturing chips is known as lithography or etching. In this technology, the chip circuit is written over by a probe literally. These building circuits in electronic chips have a limitation of around 22 nanometres. Below 22 nm errors might occur and short circuits and silicon limitations will result in derailment of manufacturing chips.

2. NANOTECHNOLOGY IN ELECTRONICS

Conventional electronic circuits are constructed by the process of etching on silicon wafers [2]. The process of Integrated Circuit (IC) commercialisation and formation of microelectronics industry started in 1965 [3]. The technology has ever-increased and circuits decreased in size from that time. Such a pace of technological advancement was first predicted by 'Moore's Law'. Some of the developments included increased transistor counts and frequency of operation [4]. Considerable reductions in circuit size have been observed over the recent years [5]. In 2000, the Field Effect Transistor (FET) was scaled to less than 100 nm, inaugurating the epoch of silicon nanoelectronics [6]. Intel now manufactures its microprocessors by making use of 65nm technology progresses [7].

3. NANOCOMPOSITE MATERIALS IN ELECTRONICS

Nano composites exhibit unusual properties and individual design possibilities. [8] They find their applications in different areas ranging from packaging to biomedical applications. Here, the three matrix Nano composites are discussed underlining the material needs, their processing methods and some latest results. Possible uses such as in clay based chrysotile, minerals and lignocellulosic fibres are presented. Being eco-friendly, Nano composites provide new platforms for aerospace, automotive, electronics and biotechnology industries [9].

3.1. Carbon Nanotubes (CNTs)

Carbon Nanotubes (CNTs) and their compounds display extraordinary electrical properties for organic materials. [10] It is used for manufacturing transistors and as conductive layers for the touch screen market. CNTs can also be considered as an alternative for transparent conductors. However cost plays an important role in implementation of these systems. Apart from TCF applications, carbon nanotubes can also be used in thin-film batteries. [11] Nanotubes structure is shown in figure A1.

Single-walled CNTs (SWCNTs) and Multiwalled CNTs (MWCNTs) are the two types of carbon nanotubes. Figure A2 shows the images of single- and multi-walled carbon nanotubes. Based on the direction of rolling, CNTs can be conductors or semiconductors. Carbon nanotubes display extraordinary properties owing to their covalent bonding [12, 14].

3.2. Fullerenes

A fullerene is a carbon molecule which may have a tube, ellipsoid or a spherical shape. They are often called buckyballs. Fullerenes and graphite have similar structure. These materials cause environmental hazards to a great extent.

3.3. Polymer matrix composite materials

[15] Unlike conventional standard fillers, Nano composite materials need only a very small nano-filler amount to yield marked developments. Moreover, all these advantages come without sacrifices in matrix resins light transmission. Nano-fillers provide extra interfacial area per particle than conventional mineral fillers [16].

3.3.1. Polymer matrix nanocomposite materials applications

Nano clay can be used to reinforce fabrics. Mechanical characteristics of polypropylene fabrics are enhanced by the addition of Nanoclay at 1 wt% [17]. Nanoclay can also be used in thermoplastic/natural fibre composites [18].

3.4. Quantum dots

3.4.1. Quantum dots definitions and markets

[19] At dimensions in the atomic range, crystalline materials behave according to the quantum physics rules. If the crystalline dimension falls below the exciton size [20] Bohr radius and the levels of electron energy become separate leading to the generation of Quantum Dots (QDs).

[21] Normally, quantum dots fall into the nanocrystals category which includes quantum rods and quantum wires. Others include quantum dots based flash memory and optoelectronics [22].

3.4.2. Quantum computing: incorporating nanotechnology into computers

Nanotechnology can contribute to computers and computing technology with the invention of quantum computers. From the analysis [23] provides a brief introduction.

Quantum computing is an area of computer science and technology that deals with an entirely new scenario. Quantum theory uses quantum computers to create a new computer technology. Quantum theory deals with matter at the level of subatomic particles.

A quantum computer signifies a novel paradigm in computer science and computer technology. It has the potential to be "the next step" in the technology of computing and to deliver incredibly faster computers with an enormous increase in the performance of computing. Quantum computers will be able to manage, transfer, store and process unbelievable electronic data amounts at very high speeds.

The "qbit" is used instead of the traditional bit in quantum computing. Today's computers use the "bit" information which can assume two values: 1 and 0. New quantum computers use the new "qbit", which can assume values anywhere between 0 and 1. This implies that they can be achieved by new types of calculations and greater processing speeds.

3.4.3. Potential applications

According to [24], the quantum computer is expected to attain staggering processing speeds in the order of a billion times per second, making it the fastest computer on earth.

Such a computer could be used in solving problems and calculations that cannot be handled by the current computers. For example, a quantum computer could be used in the modelling and simulation for environmental monitoring which is presently unbearable with the existing technology.

4. APPLICATIONS

[25] Owing to the strong inter disciplinary character of nanotechnology there are numerous applications that involve nanotechnology. This segment provides a brief overview of nanotechnology and current developments in nanoscience. Figure A3 and figure A4 shows the Nano Films and Nanotubes [26]. Apart from moving forward, NNI is also committed to address the potential environmental, health and safety issues.

Nanotechnology is already in use in communications and computing to provide faster and smaller systems that can manage and store higher amounts of information. These continuously evolving applications include Nano scale transistors, Magnetic Random Access Memories (MRAM), monitor displays and flash memory chips [27-34].

5. THE CHALLENGES

In Nano electronic materials, sensitive electrical measurement tools are essential. Sensitivity of instruments used must be much higher as electrical currents are much lower. [35] The magnitude of the currents may be in the femtoamp range and resistances may be in the order of micro-ohms. Noise reduction and signal interferences are other concerns. Next challenge is the use of cost effective tools. Some of the present tools are unnecessarily intricate and also data transfer mechanisms are often tedious. Graphical study and programming time are other factors. User-friendly instruments are important, not only to researchers and technicians, but also to design engineers and manufacturing authorities. Numerous complications may arise at the level of nanoscale testing.

[36] recommended measurement data to report carrier mobility, electrical resistivity, non-linear behaviours and conductivity. The new standard promises to greatly aid in accelerating the standard commercialization of Nano scale materials. [37] states that the necessity of pulse source has grown in time and can be a boon to existing nanotechnology based industries.

6. WHAT'S ON THE FUTURE?

Nanotechnology is bringing rapid changes to the electronics field, particularly in favour of optics, computers and telecommunications. Nanotechnology has proposed new working ways for electronic systems. A new circuit material, new processors, new means of storing information and new manners of information transferring is proposed by nanotechnology. Nanotechnology can provide better versatility because of quicker data transfer, more “on the go" processing capabilities and larger memories of data [38].

In electronics, a new field is on the rise which will prove to be a huge leap in computer and electronics science. It is the field of quantum computing and quantum technology. Quantum computing is a scientific area aimed at emerging computer technology based on the quantum theory principles. It finds its application in multiple scenarios where the concept of nanotechnology is applicable.

7. PROGRESS IN NANOTECHNOLOGY

[39, 40] provided an overview on the growth of SrGaGe wires on thermal annealing and a review of nanowire growth via vapour deposition. [41] claims that two facets of nanotechnology, “Evolutionary Nano” and “Revolutionary why Nano,” should not be confused. Evolutionary Nano refers to the miniaturization of stable Si devices. Revolutionary Nano refers to the quantum-leap miniaturization using the bottom-up method. Evolutionary Nano contributes more to industries. In the “21st century, a survey on molecular assembly Nanotechnology Research and Development Act” in the U.S. has got much attention [42]. The National Research Council (NRC) will give a final decision on self-assembly in the upcoming days [43]. Investment in the long-term based on a well planned strategy is necessary for the materialization of next generation technologies. Although the top-down and bottom-up methods to construct nano-scale materials have been given a glance, new ideas for combining both have not been well studied, except for industry research.

8. CONCLUSION

It is obvious that nanotechnology will be the root cause of industrial revolution. Today, many of our engineers and scientists are finding new ways to use nanotechnology in real life applications. Despite the research challenges ahead, nanotechnology already is producing a wide beneficial materials range and pointing to breakthrough in several fields. In this paper many Nano devices used in the field of electronics and telecommunication were discussed. Moreover an analysis of the emerging commercial applications of nano-electronics is also carried out. Long term Nanotechnology use will allow us to meet customer necessities by extending current technologies or replacing them with new ones. It is presented as a realistic, promising technology for the future due to the progress in this field. Investment in long - term based on well planned strategy is necessary for materializing technologies of next - generation, such as nanotechnology, where planning should contain steps for impressive success in industry, representing the bright future of the technology.

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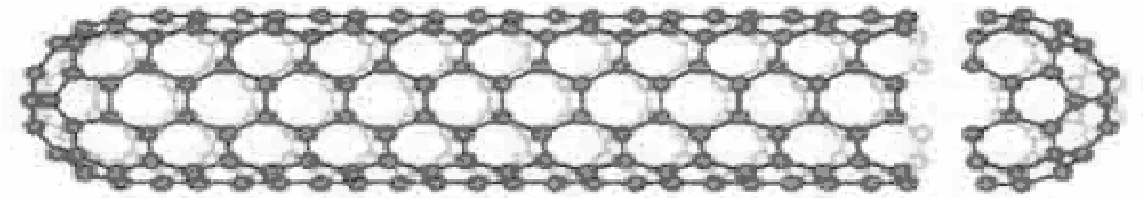
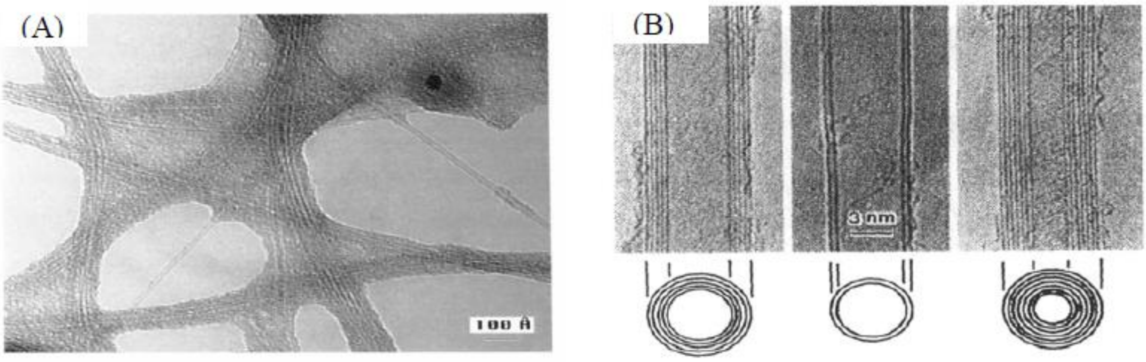
APPENDIX A



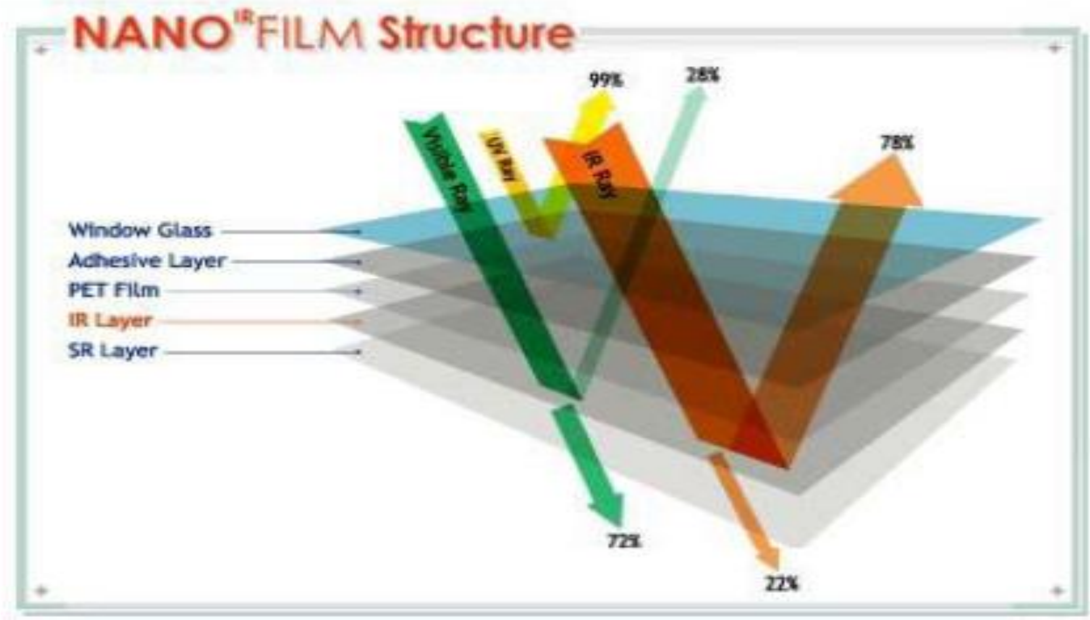
Adapted from [11]

Figure A1.Structure of carbon nanotube



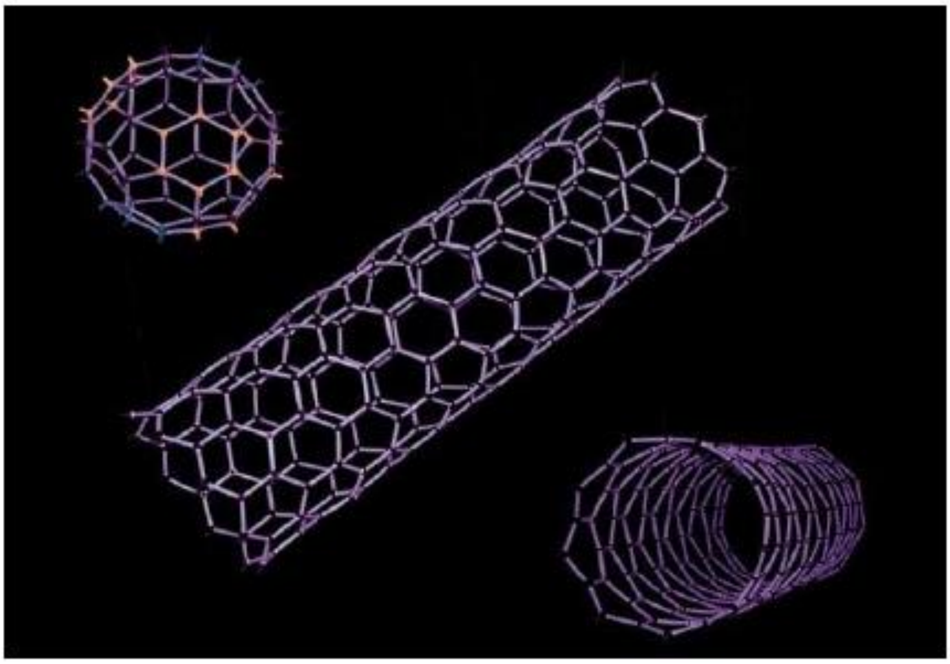
Adapted from [13]

Figure A2.Single- and multi-walled carbon nanotubes. (A): Single-walled carbon nanotube (Bethune 1993). (B): Multi-walled carbon nanotube [13].



Adapted from [26]

Figure A3.Nano films [26]



Adapted From [27]

Figure A4.Nanotubes