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NANOBASICS AND NANOTECHNOLOGY

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ABSTRACT:

A Nanotechnology age is the one in which human learned to make nano-scale materials. Like other ages, the nanotechnology is not characterized by materials like stone, bronze, iron or silicon, but it is characterized by size of materials, how big is it and how to control its dimension. Some of the future applications of nanotechnology are wearable computers, space elevators, and etc. These ideas are achievable through nanotechnology. Nanotechnology now represents no less than the next industrial revolution. Nanotechnology is nothing more than new age colloidal science. Materials central in nanotechnology are critical, of dimensions about 1 to 100 nm, really bizarre and have unusual properties. Nanotechnology contains stuff that is really small and strange. Thus definition is shifted to special property of matter having broad range research and applications because of its large potential. As nanotechnology is defined by size, it is very broad field such as physics, chemistry, molecular biology, micro fabrication, etc. Thus associated nanotechnologies and their applications are also wide, ranging from conventional semiconductor devices to molecular self- assembly, from developing new materials with dimensions on a nano scale to direct control of matter on the atomic scale. Applications of nanotechnology extend from medicines, electronics, and biomaterials to energy productions. On the other hand nanotechnology raises issues like toxicity, environmental impact of nanotechnology and their effect on global economics, etc.

KEYWORDS: Nanobasics; Nanomaterials; Applications of nanotechnology

1. INTRODUCTION

Tools and fashioning tools is one of the things that make us human. Why Nanotechnology? It is the latest human technology. Tools made from materials and therefore it is not surprising that our history is not defined by weapons but it is defined by materials. So materials are extremely important to human beings.

Table 1.1 Different ages and characteristic materials

Stone Age	Human learned to fashion tools from rock
Bronze Age	Human learned to melt bronze
Iron Age	Human learned to forge iron and steel
Information Age	Human learned to purify silicon

So materials are extremely important to human beings. What next? “---- ? ----”Age: human learned to make nano scale materials. But as far as nanotechnology is concerned, it is not characterized by materials i.e. it is not about stone, bronze, iron, or silicon, but the size of materials - how big they are and how to control their dimensions. Actual definition varies from country to country and agency to agency. Nanotechnology is a term referring to a wide range of techniques that measure, manipulate or incorporate materials and their features with at least one dimension of about 1 to 100 nm [1]. National Nanotechnology Initiatives defines nanotechnology as manipulation of matter with at least 1-D sized from 1 to 100 nm [2]. Such applications exploit those properties distinct from bulk or molecular systems of nano-scale components. Nanotechnology now represents no less than the next industrial revolution. Nanotechnology is the understanding and control of matter at dimensions of roughly 1-100 nm where unique phenomenon enables novel applications, really bizarre and unusual properties. Nanoscience and nanotechnology are the study and applications of extremely small things and can be used across all other science fields, such as chemistry, biology, physics, material science and engineering.

Table 1.2 Nanomaterials vs. Nanotechnology

Bulk	*Material*	*Device*	*Technology*
	Silicon	μP	I-pod
Nanoscale	*Nano-materials*	*nano-scale device*	*Nano-technology*
	Nano-X*	Property	LED

* Nano-X: Where X can be anything

In 1959, academic researcher Richard Feynman, father of nanotechnology, discussed in his lecture "*There's a plenty of room at the bottom*" how small we can go and raised a question why can we not write the entire 24 volumes of encyclopedia Britannica on the head of the pin? [3] Prof. Norio Taniguchi, 1974 did ultra precision manufacturing and was credited with first using the term nanotechnology [4]. In 1980, Drexler wrote "*Engines of Creation*", a book about nano-scale robots assembling matter, a fantastic science fiction [5].

There is no tool to see nanostructure. 1990s tools such as AFM and STM are emerged to see the nano scale materials and nano structures which is an important step in nanoscience to control size precisely and study properties.

2. Nanotechnology

There are two broad ways to synthesize or fabricate nano materials [6]:

1. *Top down approach* – Here, macroscopic object is carved up into little nano-meter sized pieces. For example, in semiconductor industry, a big chunk of silicon is carved up into little nano-meter sized active devices.

2. *Bottom up approach* - The idea here is to start with small components like atoms or molecules and then to persuade them by chemical methods usually to assemble into structures which are nano-meter sized

A nanomaterial typically falls into one of the following broad groups:

1. Carbon nano tubes

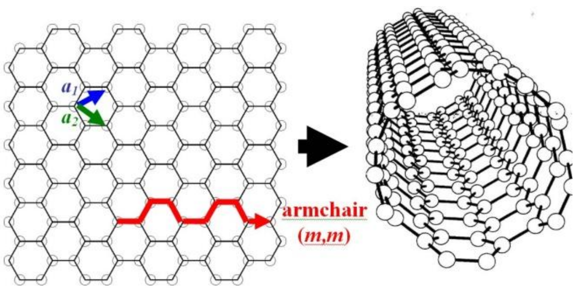

Fig. 2.1 armchair type single wall nanotube

Nanotubes are members of the fullerence structural family. Their name is derived from their long, hollow structure with the walls formed by one-atom-thick sheets of carbon, called graphene. These sheets are rolled at specific and discrete angles and the combination of the rolling angle and radius decides the properties of the nanotube, for example whether the individual nanotube shells are metal or semiconductors [7].

2. Quantum Dots –

Fig. 2.2 CdSe nano-crystals

This is the basic idea of quantum confinement and the word *quantum* is used here because it's relevant to the quantum mechanical properties of electrons, which exhibits their wave nature. So if you have a chunk of silicon that's more than, say, 20th nanometers cross, the wave nature of the electrons inside will be more or less unaffected by the size of the box in which they live. On the other hand, if you have a chunk of silicon that's only 10 nanometers across, which is half the size of the wave would naturally be, the properties of the wave nature of the electrons will be significantly changed.

Semiconductor	*Size of electron wave*
Silicon	~ 20 nm
CdSe	~ 6 nm
Gallium Arsenide	~ 10 nm

Table 2.1 - Normal wavelengths

3. Metal nano-particles – Nanoparticles are used, or being evaluated for use, in many fields such as medicine, manufacturing, environmental science, energy and electronics engineering, etc..

4. Ceramics – These are nano sized oxides of various types which have been synthesized using chemical means for quite a few decades. Nanometer-sized materials that are formed into coatings can give really unique and interesting properties. They can be super-hard for protective coatings and they can give flexibility where an ordinary coating would be brittle.

5. Dendrimers - Dendrimers have a highly ordered structure. They are considered as promising materials for drug delivery.

3. Applications

The properties of the most popular nanotech products have led researchers and companies to consider utilizing them in several fields [8].

3.1 Carbon Nanotubes

Current use and application of nanotubes has mostly been limited to the use of bulk nanotubes, which is a mass of rather unorganized fragments of nanotubes. Bulk nanotube materials may never achieve a tensile strength similar to that of individual tubes, but such composites may, nevertheless, yield strengths sufficient for many applications. Bulk carbon nanotubes have already been used as composite fibers in polymers to improve the mechanical, thermal and electrical properties of the bulk product such as tennis racket, bicycle products, air craft, stress free khakis, sport equipments like golf ball, hockey sticks, random access, base ball-bat, badminton racquet, non-volatile memory, tips for atomic force microscope probes etc.

3.2 Quantum Dots

Quantum dots are particularly significant for optical applications due to their high extinction coefficient such applications are LED, Photo detector, Photovoltaic cell etc. In electronic applications they have been proven to operate like a single electron transistor.

3.3 Metal Nanoparticles

They have a lot of interesting applications in sensing, drug delivery, printable electronics and catalysis.

3.4 Ceramics

The controlled release of drugs is one of the most exploited areas in terms of ceramic nanoparticle application in biomedicine. In this field, the dose and size are important. Also, some features that make nanoparticles a potential tool in controlling drug delivery are high stability, high load capacity, easily incorporation into hydrophobic and hydrophilic systems, and different routes of administration (oral, inhalation, etc.). In addition, a variety of organic groups which may be functionalized on its surfaces allow for a directed effect.

3.5 Dendrimers

Their structure offers various advantages such as monodisperse and controllable size, modifiable surface, functionality, multivalency, water solubility, and an available internal cavity for drug delivery. The characteristic architecture of dendrimers and the flexibility in the modification of their structure has allowed a greater progress in the application of biocompatible dendrimers for targeted drug delivery. Regarding this, there are studies on the use of biocompatible dendrimers for cancer treatment to deliver chemotherapeutic drugs such as cisplatin and doxorubicin.

4. Conclusions

As we have seen, nano materials are a huge broad class of different types of materials. Because anything that's macro almost, anything that's macro can be made nano. And depending on what the material is, one gets different advantages for doing that. So one might improve electrical properties, optical properties, mechanical properties, etc. In addition to this, one might create properties where none previously existed. There are really a wide range of different possibilities.

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