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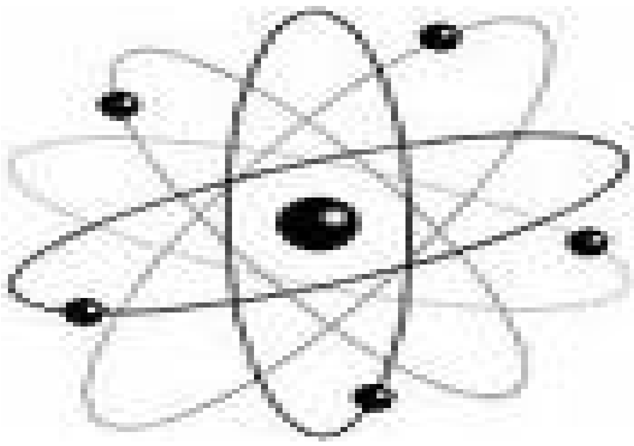

documentary research on :

Nanotechnology

Submitted by : supervised by :

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DEDICATION

"اللهم لك الحمد حتى ترضى و لك الحمد إذا رضيت و لك

الحمد بعد الرضى"

This work is for:

- *The person that I can't live without.*
- *My friends youness, issam, houssam, houssam, omar, faress, djemal.*
- *My fellows djemal, mostafa, walid, hichem, aadel, safia, kenza, loubna, loubna, assma.*
- *My country ALGERIA.*

Dhia Eddine

CAcknowledgment

Its been three years since I first came here at Mohammed Khieder University of Biskra, it's been a hard three years, but in these last three years i learned a lot of things and i met a lot of people and a great teachers and i made friends...

first I would like to thank my dear parents who have always been there for me.

my great teacher and my supervisor "Mr.abdelouahad Chala" for his help and patience.

My friends for their special support and help.

Finely i would like to thank every person who participated in the realisation of this work.

Dhia Eddine

List of Figures

SUMMARY

Introduction

the purpose of this piece of work is to reveal this new technology which is nanotechnology, recently this technology entered the field of scientific research and made a huge evolution,

In this piece of work We will look into four chapters.

In the first chapter which Regarded as a question (what is nanotechnology?) we will know what is this new technology And when it appeared and the importance of it and the risks.

In the second chapter we will present fabrication methods and tools to build a material at nanoscale.

In the third chapter we will talk about nano objects and particles and their properties at nanoscale and the last chapter we will see the applications of this technology.

CHAPTER I

What is nanotechnology?

I.1 Defenition :

Nanotechnology is building and using and manipulating materials at length scales below 100 nm (atomic, molecular and superamolecular scale), by using the devices on the same length scale. Or it is any technology on a nanoscale that has applications in the real world and encompasses the production and application of physical, chimical and biological systems at scales ranging from individual atoms or molecules [1].

I.2 How small is a nanometer?

The term nano is from the Greek word "nanos" or "nanos dwarf" which is a prefix like (mega, giga, micro …ect) and it means extremely small; precisely speaking, one-billionth or 10^{-9}

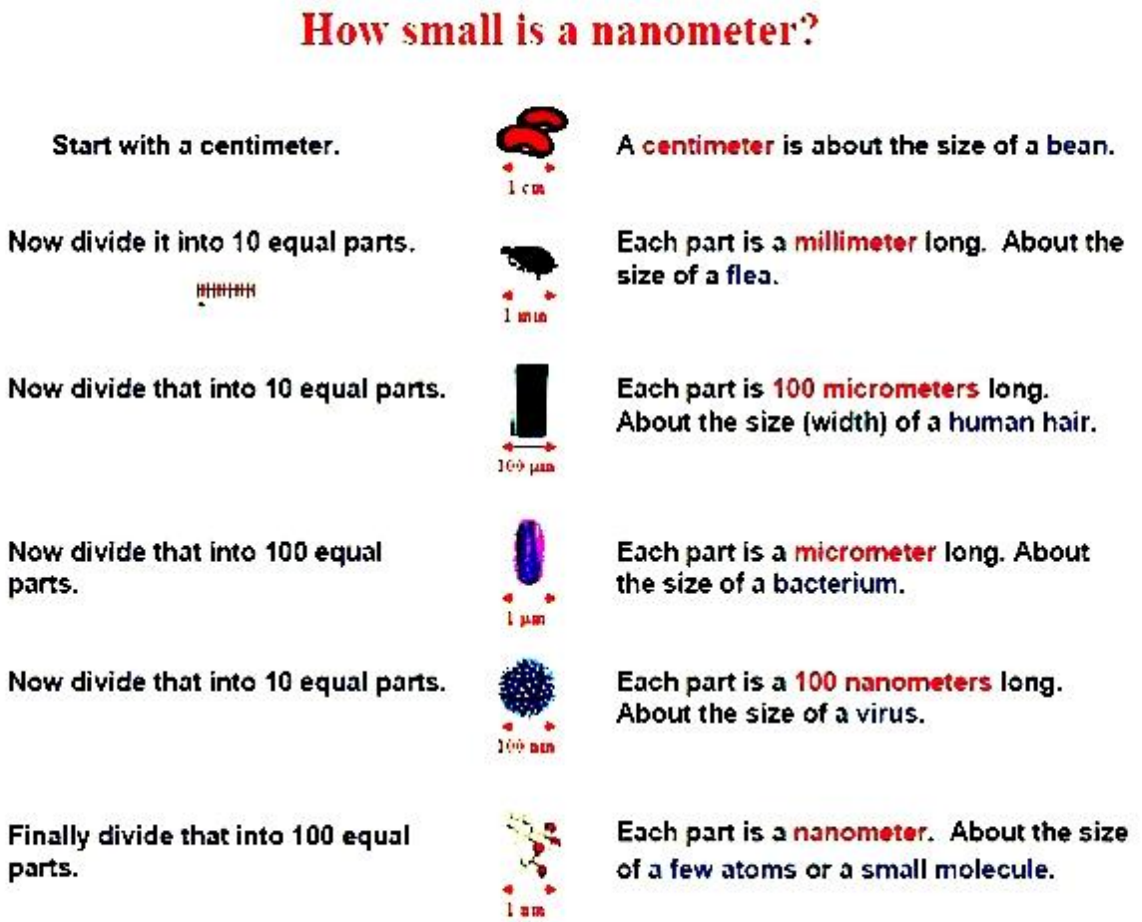

Fig.I.1 nanometer scale [2].

I.3 History of nanotechnology

Humans have unwittingly employed nanotechnology for thousands of years, for example in making steel and in vulcanizing rubber. Both of these processes rely on the properties of stochastically-formed atomic ensembles mere nanometers in size, and are distinguished from chemistry in that they don't rely on the properties of individual molecules. But the development of the body of concepts now subsumed under the term nanotechnology has been slower [3].

The first mention of some of the distinguishing concepts in nanotechnology was in 1867 by James Clerk Maxwell when he proposed as a thought experiment a tiny entity known as Maxwell's Demon able to handle individual molecules.

The topic of nanotechnology was again touched upon by "There's Plenty of Room at the Bottom," a talk given by physicist Richard Feynman at an American Physical Society meeting at Caltech on December 29, 1959. Feynman described a process by which the ability to manipulate individual atoms and molecules might be developed, using one set of precise tools to build and operate another proportionally smaller set, so on down to the needed scale. In the course of this, he noted, scaling issues would arise from the changing magnitude of various physical phenomena: gravity would become less important, surface tension would become more important.

The term "nanotechnology" was first defined by Tokyo Science University, Norio Taniguchi in a 1974 paper (N. Taniguchi, "On the Basic Concept of 'nano-technology'," Proc. Intl. Conf. Prod. Eng. Tokyo, Part II, Japan Society of Precision Engineering, 1974.) as follows: " 'nano-technology' mainly consists of the processing of, separation, consolidation, and deformation of materials by one atom or one molecule." Since that time the definition of nanotechnology has generally been extended upward in size to include features as large as 100 nm.

I.4 Annual Global Nanotechnology Research Funding

Since the US National Nanotechnology Initiative was announced in 2000 almost every developed and developing economy has initiated national nanotechnology programs. The world's governments currently spend $10 billion per year on nanotechnology research and development [4].

In the end of 2011 total government funding for nanotechnology research worldwide was $65 now it is rising to $100 billion in 2014. When figures for corporate research and various other forms of private funding are taken into account, which were thought to have surpassed government funding figures as far back as 2004, we estimate that nearly a quarter of a trillion dollars will have been inverted into nanotechnology by 2015.

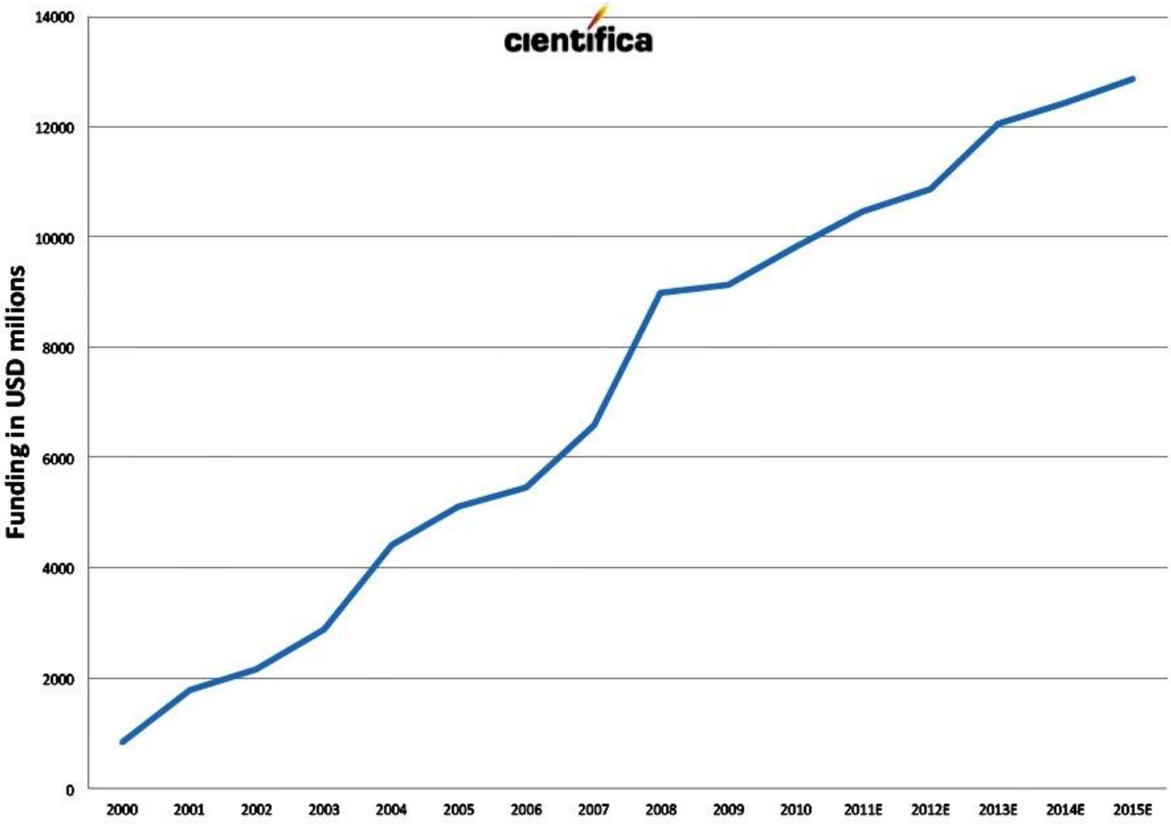

fig I.2 Annual Nanotechnology Funding Levels [4].

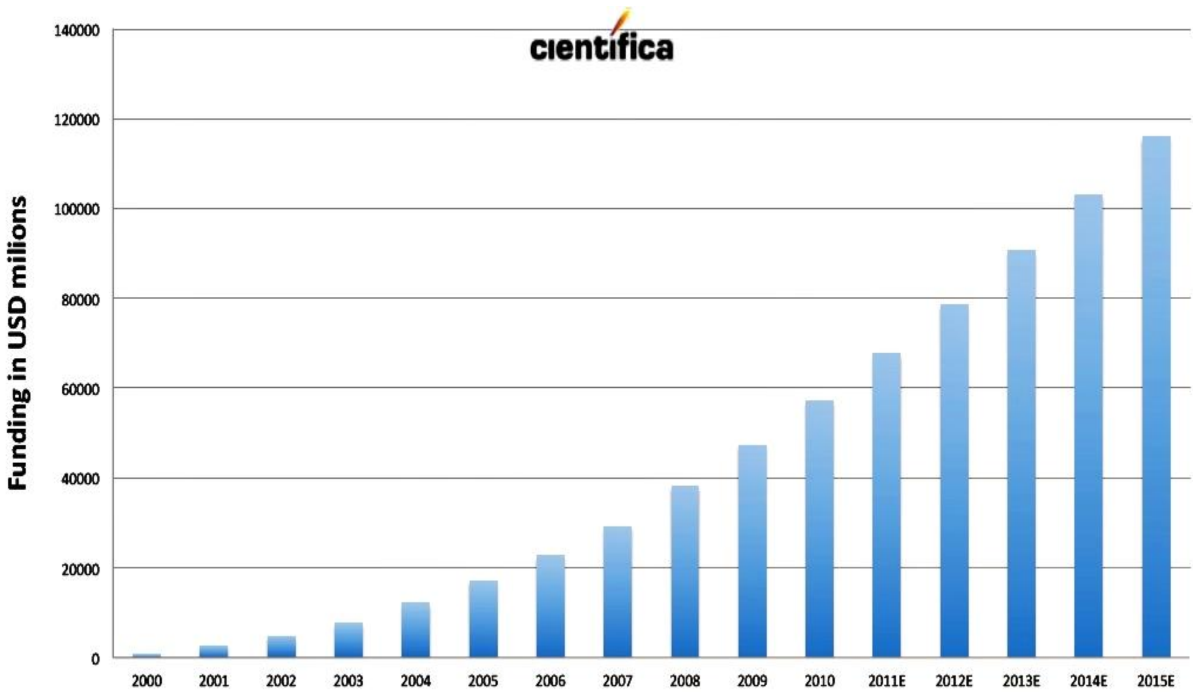

fig I.3 Total Global Nanotechnology Funding [4].

I.5 Why is nanotechnology important ?

Nanotechnology has the potential to change every part of our lives. In the last two decades, researchers began developing the ability to manipulate matter at the level of single atoms and small groups of atoms and to characterize the properties of materials and systems at that scale. This capability has led to the astonishing discovery that clusters of small numbers of atoms or molecules-nanoscale clusters-often have properties (such as strength, electrical resistivity and conductivity, and optical absorption) that are significantly different from the properties of the same matter at either the single-molecule scale or the bulk scale [5].

I.6 Nanotechnology risks

like many of the great advancements in earth's history, it is not without risk Here are some of the risks posed to society by nanotechnology [6].

Real risk: Nanopollutants

When: Now

Nanopollutants are nanoparticles small enough to enter your lungs or be absorbed by your skin. Nanopollutants can be natural or man-made. Nanoparticles are used in some of the products found on shelves today, like anti-aging cosmetics and sunscreen. The highest risk is to the workers in nano-technology research and manufacturing processes.

Potential Risk: Privacy Invasion

When: 5 to 15 years

Virtially undetectable surveillance devices could dramatically increase spying on government, Coresporations and private citizens.

Potential Risk: Economic Upheaval

When: 10 to 20 years

Molecular manufacturing is the assembly of products one molecule at a time. It could make the same products you see today, but far more precisely and at a very low cost. It is unclear whether this would bring boom or bust to the global economy.

Potential risk: Nanotech weapons

When: 10 to 20 years

Untraceable weapons made with nanotechnology could be smaller than an insect with the intelligence of a supercomputer. Possible nano and bio technology arms race.

Far-fetched risk: Gray Goo

When: 30+ years

Free range, self-replicating robots that consume all living matter. However unlikely, experts say this scenario is theoretically possible, but not for some times. We have just scratched the surface.

There are many areas of nanotechnology science that hold potential dangers to society. Bioengineering and artificial intelligence for example, have their own set of risks.

As we enter an era of unprecedented understanding, it is important that society takes a proactive role in the responsible development of nanotechnology.

CHAPTER II

fabrication methods at nanoscale

II.1 Introduction

This chapter summarizes some of the methods that are use for the fabrication of nanotmaterials, meaning materials with at least dimension in the nanoscale regime (1-100nm). These include nanostructures, nanoparticles, nanoporous materials etc. the aim of this chapter is to answer the question: how do we fabricate nanomaterials? What fabrication tools are used in nanotechnology? [7].

There are two methods for fabrication of nanomaterials and nanostructures.

Top-down methods: slicing or successive cutting of a bulk material to get nano sized particle.

Bottom-up methods: the build up of a material from the bottom (atom by atom, molecule by molecule, cluster by cluster).

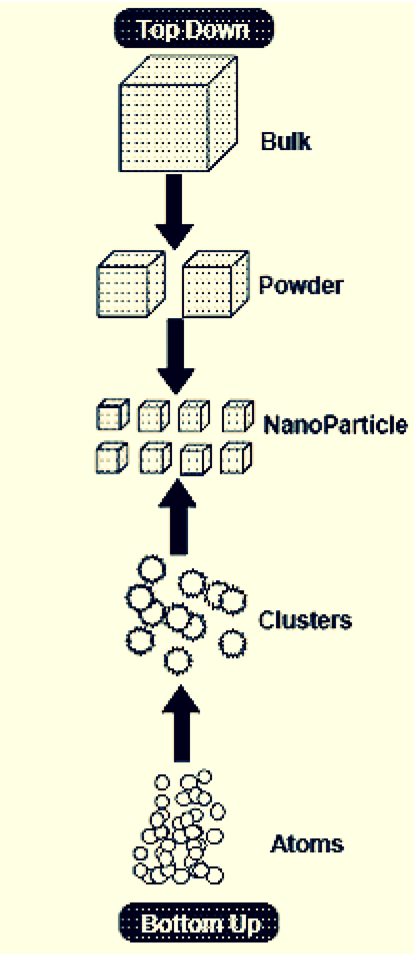

Fig II.1 Schematic representation of the building up of nanostructures *[8]*.

in both methods two requisites are fundamental: control of the fabrication conditions (e.g., energy of the elecron beem) and control of the environment conditions (presence if dust, contaminants etc) for these reasons, nanotechnologies use highly sophisticated fabrication tools that most of times operated in vacuum and are inside clean room laboratories [7].

II.2 Top-down

Many top-down fabrication methods used in nanotechnology are derived from the fabrications methods used in the semi conductor industry to fabricate the various elements of computer chips (integrated circuits).these methods are collectively called lithography (lithography can be any technique which can be used to print on a smooth surface), and we use a light or electron beam to selectively remove micron-scale structures from a precursor material called resist.

II.2.1 Photolithography

Photolithography (also called “optical lithography”) is simply lithography using a radiation source with wavelength(s) in order to make extremely small features [9]
an illustration of the photolithography process is shown in (fig II.3). the process follows the following basic step

Step 1: The wafer is spin coated with resist to form a uniform ~1 µm thin film of resist on the surface.

Step 2: The wafer is exposed with ultraviolet light through a mask which contains the desired pattern. In the simplest processes the mask is simply placed over the wafer, but advanced sub-micron technologies require the pattern to imaged through a complex optical system.

Step 3: The photoresist is developed and the irradiated area is washed away (positive resist) or the unirradiated area is washed away (negative resist).

Stap 4: Processing (etching, deposition etc.)

Step 5 : Remaining resist is stripped.

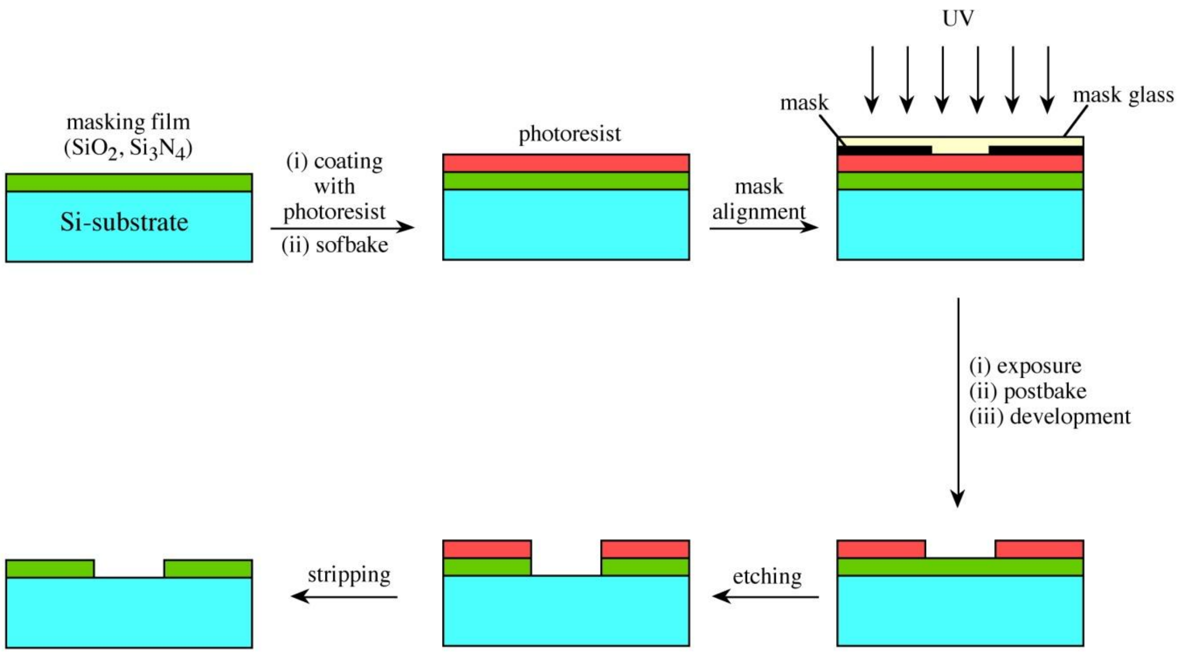

Fig.II.2 Steps in optical printing using photolithography [10].

II.2.2 Scanning lithography

Energetic particles such as electrons and ions can be used to pattern appropriate resist films leading to features with nanometer resolution. When using electrons, the technology is called electron beam lithography (**e-beam**)

E-beam: refers to a lithographic process that uses a focused beam of electrons to form the circuit patterns needed for material deposition on (or removal from) the wafer, in contrast with optical lithography which uses light for the same purpose. Electron lithography offers higher patterning resolution than optical lithography because of the shorter wavelength possessed by the 10-50 keV electrons that it employs [11].

II.2.3 Soft lithography

Soft Lithography is an umbrella term for a set of techniques that rely on printing and molding to make microstructures and nanostructures. It was originally developed in order to circumvent the limitations of photolithography, which has been the basic technology used for making all microelectronic systems. The invention of photolithography is arguably as important as that of the wheel, bronze, or movable type in terms of its impact on society. It is, however, a technology that is specialized for use in microelectronics [12]

It is important to emphasize that while Soft Lithography clearly is of value for electronics, it is by no means limited to this field. In fact, Soft Lithography is finding application in a range of different fields from consumer products to industrial processes to life sciences, because the fundamental capability it enables is critical to so many development challenges: the exquisite control over an infinite range of structures and chemistries from the nano- to the meso-scale, and the integration of these into useful systems and devices.

The basic principle of the first phase for any Soft Lithographic technique is illustrated below. We start with the fabrication of a 'Master' using proven techniques, such as photolithography, e-beam, or micro-machining. A Master could also be an existing structure that doesn't require processing like a human hair or some woven fabric. An elastomer, such as polyurethane or a silicone, is poured onto the Master, hardened using heat or ultraviolet light, and peeled off to yield a 'mold'. The resulting mold is the exact structural inverse of the original Master - down to nanometer accuracy depending on the combination of materials used and the precision of the replication process

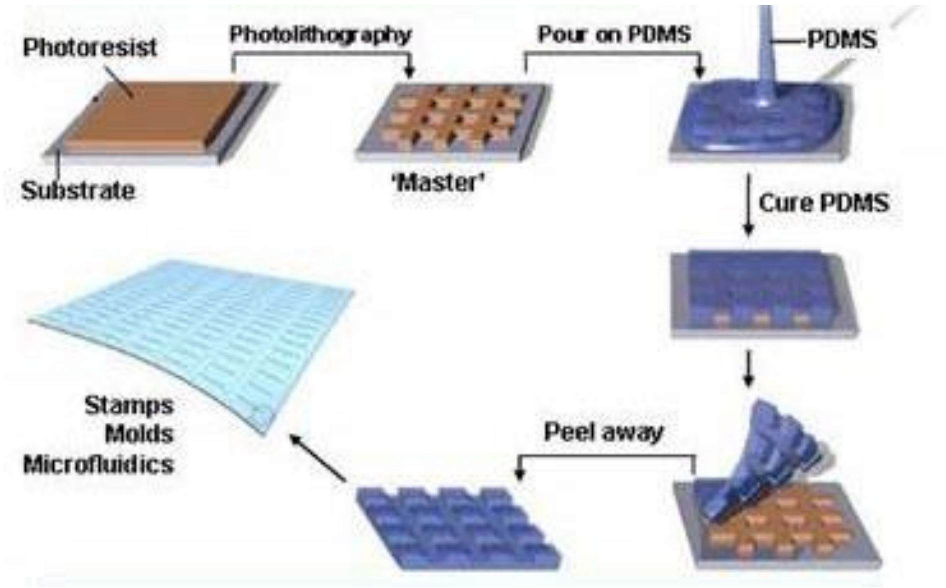

Fig.II.3 Schematic illustration of the procedures for fabricating soft lithography [12]

II.2.4 Nanocontact printing

Microcontact printing is useful for patterning features with lateral dimension of 500nm or larger. One of the major challenges for μCP has been achieving the capability of printing with high resolution, i.e with later dimension lower than 100 nm. This has been recently achieved by improving the stability of the PDMS, which being soft and highly compressible, has a tendency of deforming and collapse. One way to improve the stability of the patterns is to affix to a stiff backplane or to change the chemical formulation of the stamp itself, in order to obtain a harder polymer. With these modifications, it is now possible to print features as small as 50 nm. This printing 'method' that uses harder stamps is called nanocontact printing (nCP).

II.2.5 Scanning probe lithography

(SPL) describes recent advances in the field of scanning probe lithography, a high resolution patterning technique that uses a sharp tip in close proximity to a sample to pattern nanometer-scale features on the sample. SPL is capable of patterning sub-30nm features with nanometer-scale alignment registration. It is a relatively simple, inexpensive, reliable method for patterning nanometer-scale features on various substrates. It has potential applications for nanometer-scale research, for maskless semiconductor lithography, and for photomask patterning [13].

Scanning probe microscopy uses small (<50 nm) tips to image with atomic resolution, this ability suggest opportunities for their use in generating nanostructures and nanodevices. In this form they are referred to as (SPL),which uses the tip of an AFM to selectively remove certain areas on surface and "Dip-pen nanolithography" (DPL), which, similarly, uses the AFM tip to deposit material on a surface with nanometer resolution[

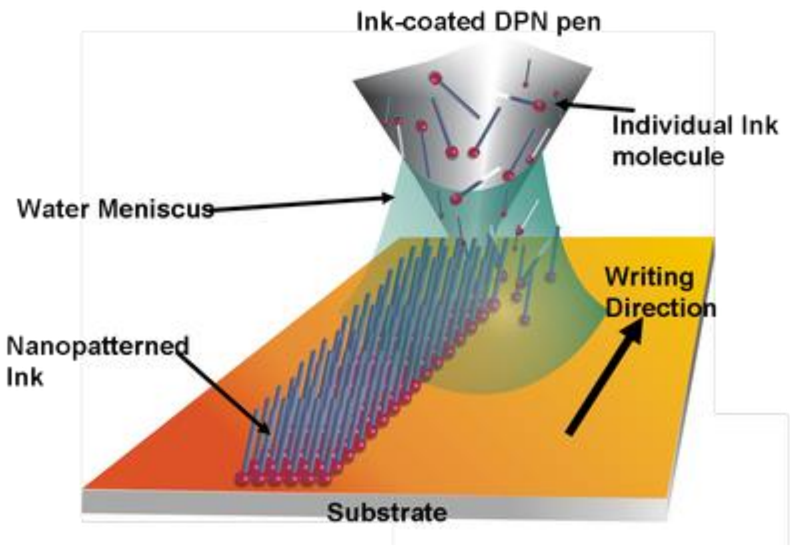

Fig.II.4 schematic drawing of the Dip-Pen Nanolithography (DPN) technique [14]

II.3 Bottom up

Bottom-up, or self-assembly, approaches to nanofabrication use chemical or physical forces operating at the nanoscale to assemble basic units into larger structures. As component size decreases in nanofabrication, bottom-up approaches provide an increasingly important complement to top-down techniques. Inspiration for bottom-up approaches comes from biological systems, where nature has harnessed chemical forces to create essentially all the structures needed by life [15].

These methods can be divided in gas-phase and liquid-phase methods.

- Gas-phase methods: these include plasma arcing and chemical vapour deposition
- Liquid phase: the most established method is sol-gel synthesis; molecular self-assembly is emerging as a new method.

II.3.1 Plasma arcing

plasma is an ionized gas, it is achieved by making a gas conduct electricity by providing a potential difference across two electrodes

Arcing: Form an electrical arc, Electrical conduction through a gas in an applied electric field.Carbon nanotubes are prepared by putting an electric current across two carbonaceous [Relating to or consisting of or yielding carbon] electrodes [graphite] as in a rare gas atmosphere generally in a helium or argon atmosphere [16]

This method is called the plasma arcing method. in this method, evaporation of one electrode [anode] takes place as cations, and the particles are deposited at the other electrode. the deposition on the cathode are nanotubes. Normally, Multi-Walled nanotubes are formed from plasma arcing. Single walled nanotubes are formed if the electrodes are bored out and cobalt or other metals are included.

II.3.2 Chemical vapour deposition

In 1993, Chemical vapor deposition (CVD) technique was first reported to produce MWNTs by Endo and his research group. Three years later, Dai in Smalley’s group successfully adapted CO-based CVD to produce SWNTs [17]. CVD technique can be achieved by taking a carbon source in the gas phase and using an energy source, such as plasma or a resistively heated coil, to transfer energy to a gaseous carbon molecule. The CVD process uses hydrocarbons as the carbon sources including methane, carbon monoxide and acetylene. The hydrocarbons flow through the quartz tube being in an oven at a high temperature (~ 720 C). Schematic diagram of the chemical vapor deposition apparatus is shown in Fig.II.6 . At high temperature, the hydrocarbons are broken to be the hydrogen carbon bond, producing pure carbon molecules. Then, the carbon will diffuse toward the substrate, which is heated and coated with a catalyst (usually a first row transition metal such as Ni, Fe or Co) where it will bind. Carbon nanotubes will be formed if the proper parameters are maintained. The advantages of the CVD process were low power input, lower temperature range, relatively high purity and, most importantly, possibility to scale up the process. This method can produce both MWNTs and SWNTs depending on the temperature, in which production of SWNTs will occur at a higher temperature than MWNTs.

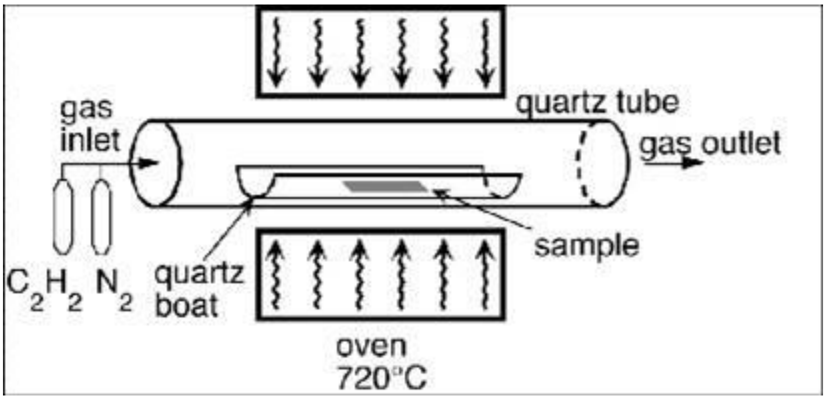

Fig.II.5 Schematic diagram of the chemical vapor deposition apparatus [18].

II.3.3 Sol-gel synthesis

Sol-gels are versatile materials made by condensing a solution (sol) of metal oxide precursors into three dimensional networks. The gels are bi-phasic systems in which a continuous fluid phase fills the space inside a polymerized network. The gels can be dried in controlled fashion to produce porous solids with unique thermal, mechanical, optical and chemical properties. Sol-gel materials have grown in importance over the past 30 years as chemists and engineers have learned how to vary the reactants and processing conditions to tailor material properties for specific applications.

The early work with sol-gels focused on those made of silica, derived by condensation of silanols groups (Si-OH), as illustrated in by reaction (1) [19]

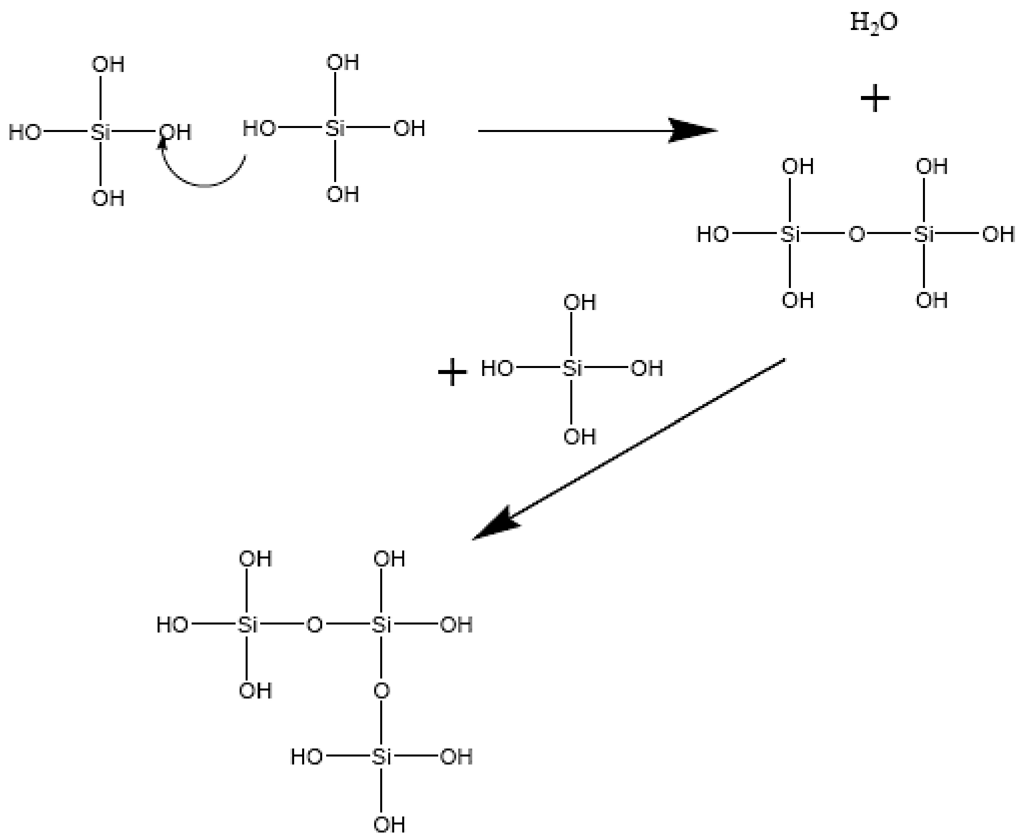

Fig.II.6 Reaction **1.** Condensation of silanols into a gel. The silanols condense by forming water leading to a network of Si-O-Si bonds. The quaternary functionality of the Si results in a three dimensional network [19].

The silanols groups may be on the surface of nanometer sized silica particles or could be formed by hydrolysis of silicone alkoxides as illustrated in reaction (2).

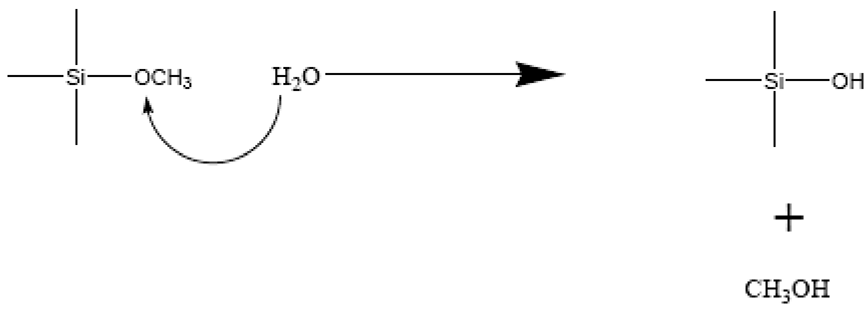

Fig.II.7 Reaction **2.** Hydrolysis of silicon alkoxides to produce silanols. The silanols subsequently undergo condensation reactions to produce silica gels [19].

II.3.4 Molecular self-assembly

self-assembly is a manufacturing method used to construct things at the nanometre-scale. Many biological systems use self-assembly to assemble various molecules and structures. Imitating these strategies and creating novel molecules with the ability to self-assemble into supramolecular assemblies is an important technique in nanotechnology. In self-assembly the final (desired) structure is 'encoded' in the shape and properties of the molecules that are used, as compared to traditional techniques, such as lithography, where the desired final structure must be carved out from a larger block of matter. Self-assembly is thus referred to as a 'bottom-up' manufacturing technique, as compared to lithography being a 'top-down' technique. The synthesis of molecules for self-assembly often involves a chemical process called convergent synthesis. Microchips of the future might be made by molecular self-assembly. An example of self-assembly in nature is the way that hydrophilic and hydrophobic interactions cause cell membranes to self assemble [20].

CHAPTER III

nano-objects and their properties

III.1 Introduction

Nanoparticles are nanometer-size materials with unique physical and chemical properties and have been widely used for many years. Organic molecules, also in the nanometer-size range, possess functionalities that enable recognition and self-assembly [21].

The combination of nanoparticles and chemical or biological molecules is very attractive and has gained tremendous attention from academics and industry, because such a combination could create new materials for electronics and optics and lead to new applications in genomics, proteomics, and biomedical and bioanalytical areas. For environmental applications, nanometer-size particles and their self-assemblies offer thr potential of novel functional materials, processes and devices with unique recognition activities, enhanced mobility in environmental media and desired application flexibility. Many nano-based environmental technologies are under very active research and development, and are expected to emerge as the next generation environmental technologies to improve or replace various conventional environmental technologies in the near future,

III.2 Quantum Dots

Quantum dots are very, very tiny particules on the order of a nanometer in size. They are composed of a hundred to a thousand atoms. These semiconductor materials can be made from an element, such as silicon or germanium, or a compound, such as CdS or CdSe. These tiny particles can differ in color depending on their size. Below is a collection of CdSe quantum dot nanoparticles that different in size as a result of how long they were allowed to form in the synthersis reaction that is described in the "Lab Manual for Nanoscale Science and Technology", Preparation of CdSe Quantum Dot Nanoparticles .

Color is well known to be influenced by particle size in both quantum dots and nanoparticles.

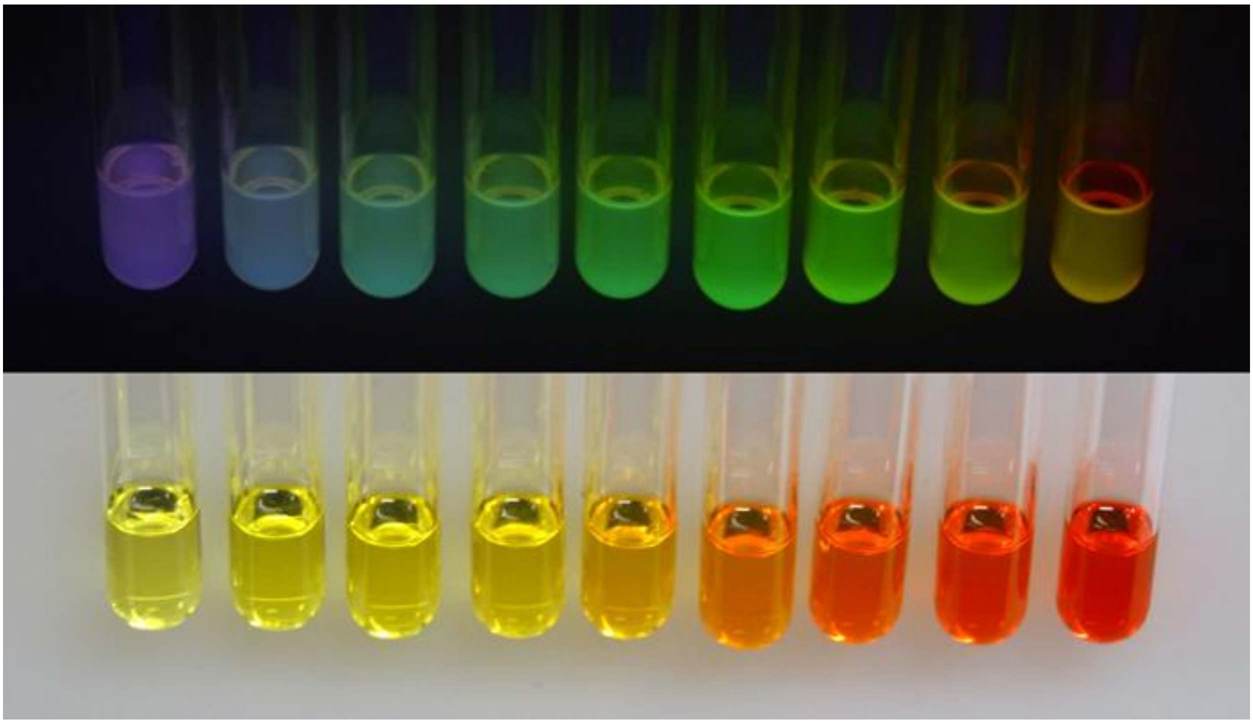

Fig.III.1 Top: Long wave UV illumination. Bottom: Ambient illumination. Solutions are in order of increasing particle size (longer growth time).

III.3 Carbon nanotubes

Carbon nanotubes are unique tubular structures of nanometer diameter and large length/diameter ratio. The nanotubes may consist of one up to tens and hundreds of concentric shells of carbons with adjacent shells separation of _0.34 nm. The carbon network of the shells is closely related to the honeycomb arrangement of the carbon atoms in the graphite sheets. The amazing mechanical and electronic properties of the nanotubes stem in their quasi-one-dimensional (1D) structure and the graphite-like arrangement of the carbon atoms in the shells. Thus, the nanotubes have high Young’s modulus and tensile strength, which makes them preferable for composite materials with improved mechanical properties. The nanotubes can be metallic or semiconducting depending on their structural parameters. This opens the ways for application of the nanotubes as central elements in electronic devices including

field-effect transistors (FET), single-electron transistors and rectifying diodes. Possibilities for using of the nanotubes as high-capacity hydrogen storage media were also considered. This report is intended to summarize some of the major achievements in the field of the carbon nanotube research both experimental and theoretical in connection with the possible industrial applications of the nanotubes [22].

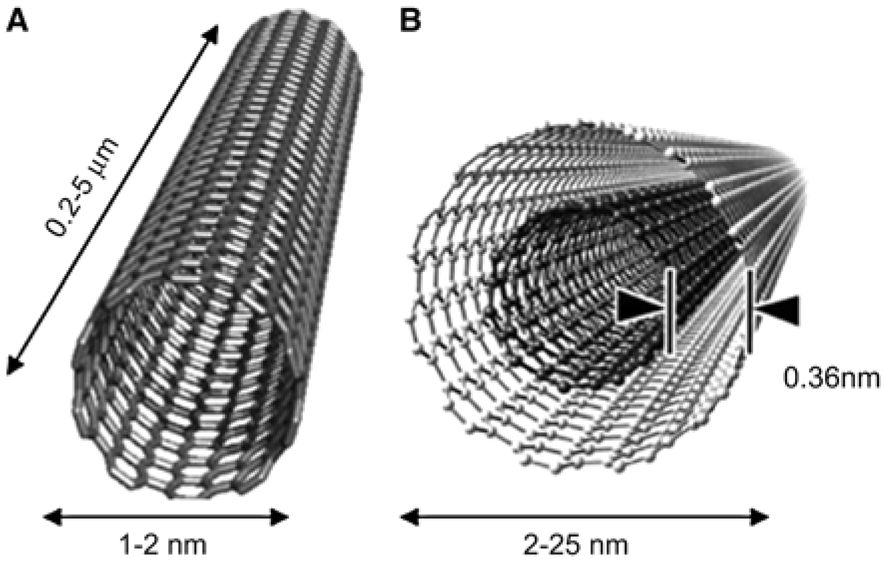

Fig.III.2 conceptual diagram of single-walled carbon nanotube (SWCNT) (A) and multiwalled carbon nanootube (MWCNT) (B) delivery systems showing typical dimensions of length, width, and separation distance between graphene layers in MWCNTs [21].

III.4 Nanolayers

A nanolayer is exactly what it sounds like: a layer of material no thicker than a few nanometers. Nanolayers are more commonly known as quantum wells. To make a quantum well, all you have to do is sandwich a material with a small bandgap with two materials that have significantly higher bandgaps. The result is that electrons excited in the middle layer cannot escape into the outer layers since they don't have the requisite energy to make the jump into the higher bandgap [23].

A laser takes advantage of this fact by creating a very thin layer of semiconductor sandwiched between similar semiconductors with high bandgaps and similar lattice constants. A good example of this is the III-V compound semiconductor, Gallium Arsenide (GaAs) that is a direct bandgap light emitter with fast switching properties. You can lattice match Aluminum-Gallium Arsenide (AlGaAs) almost exactly. AlGaAs is not like GaAs. It has a similar structure but acts more like an insulator.

By trapping electrons in the GaAs and then stimulating electrons with a voltage, you get a large number of excited electrons. While you've got the workings of a modern laser right there, a few other important steps have to be finished. First of all, let's assume you have a rectangular quantum well. In this model, we have 4 edges where the GaAs is exposed to the surface and the external environment. Ideally we should surround the entire quantum well with reflectors. Why? When the excited electrons fall back to their ground states, they will emit photons of a specific energy. We don't' want to lose the photons right away otherwise we'll never achieve coherent emission of monochromatic photons. The photons will need to bounce around the quantum well (thanks to the reflectors) and aid in the stimulation of more photons of the exact same wavelength. When a condition called population inversion is reached, a photon can trigger an entire chain of electrons to cascade back to their ground states and emit more light of the same wavelength. This sequence of events is known as light amplification by stimulated emission of radiation, or LASER for short. It is the way all modern lasers are made. Choosing the right semiconductor mix in the quantum well can tune the laser's frequency within a specific range.

So while nanolayers are not really a new invention, they are still one of the fundamental structures of nanotechnology. New advances in their fabrication offer hope in taking the idea even further. One instance of a new approach to quantum well fabrication is the inclusion of highly mismatched layers of semiconductor that can function despite the tremendous strain involved.

III.5 carbon nanosphere (fullerenes)

Fullerenes, which were discovered in 1985 by Kroro, curl and smalley (and for which the Nobel prize was awarded in 1996). The archetypal fullerene C_{60}, also known as buckminsterfullerene, C_{60} is composed entirely of carbon (no hydrogens), and each of the 60 carbon atoms is sp^2 hybridized [24].

The pattern of carbon bonding is exactly the same as the pattern on the surface of a soccer ball, Radius with 500 nm or more. The are 20 hexagonal carbon rings and 12 pentagonal carbon rings. In order to accommodate this structure. Some of the bond angles are distorted from the ideal 120° corresponding to sp^2 hybridization, with a value of 108°. Combining the 60 pz orbitals gives MOs that are spread over the entire molecule.

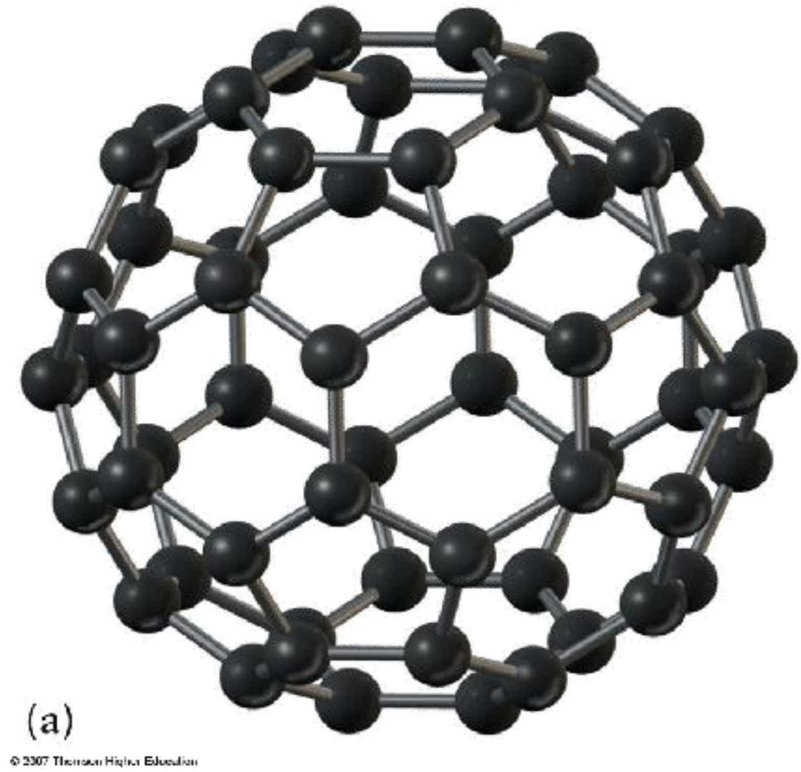

Fig.III.3 C_{60} fullerene [24].

CHAPTER IV

Nanotechnology Applications

IV.1 Introduction

The targeted application of nanotechnology has enormous potential to bring about major improvements in the living standards of people in the developing world," said Dr. Peter Singer, one of the authors of the study. "Science and technology alone are not going to magically solve all the problems of developing countries but they are critical components of development. Nanotechnology is a relatively new field that will soon be providing radical and relatively inexpensive solutions to critical development problems [25].

The authors point out that several developing countries have launched their own nanotechnology initiatives in order to strengthen their capacity and sustain economic growth. For example, India's Department of Science and Technology will invest $20 million over 2004-2009 for their Nanomaterials Science and Technology Initiative.

IV.2 Nanotechnology in energy

Nanotechnologies provide the potential to enhance energy efficiency across all branches of industry and to economically leverage renewable energy production through new technological solutions and optimized production technologies. Nanotechnology innovations could impact each part of the value-added chain in the energy sector: [26]

IV.2.1 Energy sources:

Regenerative:

Photovoltaics: nano-optimized cells (polymeric, dye, quantum dot, thin film, multiple junction), antireflective coating

Wind energy: nano-composites for lighter and stronger rotor blades, wear and corrosion protection nano-coatings for bearings ans power trains etc.

Geothermal: nano-coatings and –composites for wear resistant drilling equipment

Hydro-/tidal power: nano-coatings for corrosion protection

Biomass energy: yield optimization by nano-based precision farming (nanosensors, controlled release and storage of pesticides and nutrients

Fossil fuels:

Wear and corrosion protection of oil and gas drilling equipment, nanoparticles for improved oil yields.

Nuclear:

Nano-composites for radiation shielding and protection(personal equipment, container etc.), long term option for nuclear fusion reactors.

IV.2.2 Energy change:

Gas turbines: Heat and corrosion protection of turbine blades (e.g. ceramic or intermetallic nano-coatings) for more efficient turbine power plants.

Thermoelectric: Nanostructured compounds (interface design, nanorods) for efficient thermoelectrical power generation(e.g. usage of waste heat in automobiles or body heat for personal electronics (long term)).

Fuel cells: Nano-optimized membranes and electrodes for efficient fuel cells (PEM) for applications in automobiles/mobile electronics.

Hydrogen generation: Nano-catalysts and new processes for more efficient hydrogen generation (e.g. photoelectrical, electrolysis, biophotonic).

Combustion engines: Wear and corrosion protection of engine components (nanocomposites/-coatings, nanoparticles as fuel additive etc.).

Electrical motors: Nano-composites for superconducting components in electromotors (e.g. in ship engines).

IV.2.3 Energy distribution:

Power transmission:

High-voltage transmission: nanofillers for electrical isolation system, soft magnetic nano-materials for efficient current transformation.

Super conductors: optimized high temperature SC's based on nanoscale interface design for loss-less power transmission.

CNT power lines: super conducting cables based on carbon nanotubes (long term).

Wireless power transmission: power transmission by laser, microwaves or electromagnetic resonance based on nano-optimized components (long term).

Smart grids: nanosensors (e.g. magnetoresistive) dor intelligent and flexible grid management capable of managing highly decentralized power feeds.

Heat transfer: efficient heat in-end outflow based on nano-optimized heat exchangers and conductors (e.g. based on CNT-composites) in industries and buildings.

IV.2.4 Energy storage:

Electrical energy:

Batteries: optimized li-ionbatteries by nanostructured electrodes and flexible, ceramic separator-foils, application in mobile electronics, automobile, flexible load management in power grids (mid term).

Supercapacitors: nanomaterials for electrodes (carbon-earogels, CNT, metal(-oxides) and electrolytes for higher energy densities).

Chemical energy:

Hydrogen: nanoporous materials (organometals, metal hydrides) for application in microfuel cells for mobile electronics or in automobiles(long term).

Fuel reforming/refining: nano-catalysts for optimized fuel production (oil refining, desulphurization, coal liquefaction.

Fuel tanks: gas tight fuel tanks based on nano-composites for reduction of hydrocarbon emissions.

Thermal energy:

Phase change materials: encapsulated PCM for aircondioning of buildings.

Absorptive storage: nano-porous materials (e.g. zeolites) for reversible heat storage in buildings and heating nets.

IV.2.5 Energy usage:

Thermal insulation:

Nanoporous foams and gels (earogels, polymer foams) for thermal insulation of buildings or industrial processes.

Air conditioning:

Intelligent management of light and heat flux in buildings by electrochromic windows, micro mirror arrays or IR reflectors.

Lightweight construction:

Lightweight construction materials using nano-composites (carbon nanotubes, metalmatrix-composites, nano coated light metals, ultra performance concrete, polymer-composites).

Industrial processes:

Substitution of energy intensive processes based on nanotech process innovations (e.g. nano-catalysts, self-assembling processes etc.).

Lighting:

Energy efficient lighting systems(e.g. LED, OLED).

IV.3 The food industry and nanotechnology

The food industry is under a great deal of pressure. Crop disease and drought continually threaten the profit margins of the $600bn agricultural sector at a time when transport raw material costs are at a record high, and put millions of lives at risk through famine [27].

In addition, the threat of bioterrorism has made food safety along the supply chain a government as well as an industry priority. And if all this weren't bad enough, the industry also finds itself under increasing pressure from environmental groups and governments to clean up its act.

Nanotechnology is attractive to global food production because it promises the possibility of new answers to these key challenges. Interestingly, a recent study by the University of Toronto Joint Centre for Bioethics, which ranked ten nanotechnology applications currently in development with the greatest potential to aid the poor, put agricultural productivity enhancement second. The possibilities of maximizing agricultural productivity are evidently huge.

Crop and animal disease threaten productivity at the very beginning of the supply chain. The application of fertilizers and pesticides is strictly regulated — more so within the EU — and has become a controversial topic due to claims that some products can damage the environment and even get into the food chain. In addition, medicines are often only applied once disease symptoms are evident.

Nanotechnology could create cleaner agriculture and more targeted, preventative treatment. Scientists such as those at the Zettl Research Group at the University of Berkeley believe they are close to developing methods of near real time pathogen detection and location reporting by integrating nanotechnology micro-electromechanical systems (MEMS) with new chip designs.

These nanotech smart treatment delivery systems could be used to detect early signs of disease in crops based on detection of changes in metabolism and respiration. Productivity would be increased through catching disease early and treating specific cases without the need to resort to the widespread use of pesticide.

In addition the global livestock industry is desperate to install measures that would guarantee the safety of the food supply. Outbreaks of disease have resulted in export bans and collapsed markets. Japan for example banned US beef and beef products after a single case of BSE in an

8-year-old cow imported into the United States from Canada was detected in December 2003, and is showing resistance to fully reopening its borders.

In the UK, the BSE crisis in the late 1990s led to a 40 per cent domestic decline in beef sales and the complete loss of many export markets.

The fortunes of this sector could therefore be transformed if supplies could be guaranteed to be completely safe. Scientists at the Kopelman Laboratory at the University of Michigan are developing non-invasive bioanalytical nanosensors that could perhaps be placed in, say, a cow's saliva gland in order to detect single virus particles long before they have had a chance to multiply and long before disease symptoms are evident.

This issue of food safety has also been heightened by the spectre of bioterrorism. A Deloitte Touche Tohmatsu report entitled 'Prospering in the Secure Economy' suggested that the security breach of just one shipping container could cost companies up to $1 trillion. "Global business organisations are now squarely in the front line when it comes to protecting their supply chain, their data, their brand, and their very existence," said Jerry Leamon, Deloitte global managing partner for clients & markets.

IV.4 Nanotechnology and water treatment

(*Nanowerk Spotlight*) Only 30% of all freshwater on the planet is not locked up in ice caps or glaciers (not for much longer, though). Of that, some 20% is in areas too remote for humans to access and of the remaining 80% about three-quarters comes at the wrong time and place - in monsoons and floods - and is not always captured for use by people. The remainder is less than 0.08 of 1% of the total water on the planet (Source: World Water Council). Expressed another way, if all the earth's freshwater were stored in a 5-liter container, available fresh water would not quite fill a teaspoon. The problem is that we don't manage this teaspoon very well. Currently, 600 million people face water scarcity. Depending on future rates of population growth, between 2.7 billion and 3.2 billion people may be living in either water-scarce or water-stressed conditions by 2025 [28].

The potential impact areas for nanotechnology in water applications are divided into three categories, i.e., treatment and remediation, sensing and detection, and pollution prevention" Prof. Eugene Cloete tells Nanowerk. "Within the category of *treatment and remediation*, nanotechnology has the potential to contribute to long-term water quality, availability, and viability of water resources, such as through the use of advanced filtration materials that enable greater water reuse, recycling, and desalinization. Within the category of *sensing and detection*, of particular interest is the development of new and enhanced sensors to detect biological and chemical contaminants at very low concentration levels in the environment, including water.

IV.5 Nanotechnology and health

Nanotechnology-the science of the extremely small- holds enormous potential for healthcare, from delivering drugs more effectively, diagnosing diseases more rapidly and sensitively, and delivering vaccines via aerosols and patches [29]. For example, a major challenge of modern medicine is that the body doesn't absorb the entire drug dose given to a patient. Using nanotechnology, scientists can ensure drugs are delivered to specific areas in the body with greater precision, and the drugs can be formulated so that the active ingredient better permeates cell membranes, reducing the required dose.

Conclusion

This piece of work show that nanotechnology will change peoples' lives with it's applications that entered to the world with a new face, these applications can reduce power usage, contamination, and further Lift the country's and the worlds financial state.

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الملخص:

تقنية النانو هي التقنية القادرة على تحقيق درجات عالية من الدقة في وظائف وأحجام وأشكال المواد ومكوناتها، وهذا بدوره يساعد على التحكم في وظائف الأدوات المستعملة في ميادين الطب والصناعة والهندسة والزراعة والعقاقير والاتصالات والدفاع والفضاء وغيرها...

ABRIDGEMENT

Nanotechnology is the development and engineering of devices so small that they are measured on a molecular scale. This emerging field involves scientists from many different disciplines, including physicists, chemists, engineers, information technologists, and material scientists, as well as biologists. Nanotechnology is being applied to almost every field imaginable, including electronics, magnetics, optics, information technology, materials development and biomedicine.