Nanorobotics: Applications in Bionanotechnology

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INTRODUCTION

Nanorobotics is a young and a challenging discipline of nanotechnology that is related to the design and simulation of robots or nonbiological machines on the scale of a nanometer (10^{-9} meter/1billionth of a meter). *Nanorobotics* is also termed as the science of studying nanomachines, commonly known as Nanorobots (nanobots or nanoids), which are in the range of 0.1-10 micrometres[1].

BACKGROUND

"There's Plenty of Room at the Bottom"[2]

This was the title of the first talk on nanotechnology given by the famous physicist, Nobel Prize winner Richard Feynman, in 1959.

Feynman offered $1000 to anyone who could either build a motor that would fit inside a 1/64" x 1/64" x 1/64" box, or write a page of text with letters that are small enough for the Encyclopedia Britannica to be printed on a pin head. As soon as Feynman announced these two prizes, the first one got claimed right away. Bill McLellan, who had really good hands, made a small motor almost immediately to fit inside the box of 1/64" x 1/64" x 1/64" without creating any new technology. However, the second Feynman prize did not get claimed until very late (1985). Tom Newman and Fabian Pease (Stanford University) used electronic beam lithography technique to write *A Tale Of Two Cities* at the length scale requested by Feynman. Hence, based on Richard Feynman's vision of miniature factories using nanomachines to build complex products, "nanotechnology" evolved over the years as the nascent, yet one of the most promising, fields of technology.

Nanotechnology is an extremely diversified field with its applications in numerous areas including medicine, chemistry and environment, information and communication, energy, and consumer goods. Out of these areas, medicine or life sciences is perhaps the most targeted application of nanotechnology. This area of study of nanotechnology in the field of biology and medical sciences is coined as *Bionanotechnology* or *Nanobiotechnology*. Nanotechnology led to the development of the novice field of Nanorobotics, which came into existence in 1980s. This area of study was majorly focused towards the generation of machines at nanoscale that would be capable of manipulating the nanoparticles.

In 1986, Dr. K. Eric Drexler[3] published his research on nanosystems, in which he discussed a field that would be derived largely from the macroscopic robots. Later, this field segregated into two parallel categories: one comprised the design and simulation of robots with nanoscale dimensions, while the other embraced the idea of manipulation or assembly of nanoscale components using macroscopic instruments.

The first technical paper on nanomedical device design was published in 1998 by Robert A. Freitas Jr., J.D. titled "A Mechanical Artificial Red Cell: Exploratory Design in Medical Nanotechnology," which was the first book-length technical discussion of the medical applications of nanotechnology and medical nanorobotics[4].

As of now, a major part of the study in nanorobotics is being conducted in the field of biology and life sciences (i.e., bionanotechnology). Therefore, medical technology will be the first one to extract the advantages of this upcoming technology.

ARCHITECTURE OF NANOROBOTS[5]

In manufacturing nanorobots, the ambient conditions under which a nanorobot is operating like temperature range, pressure, density, electromagnetism (including light, and so on) are taken into consideration. (Medically, in future, these conditions may be the considered inside the veins of a human body where a nanorobot will carry out its functions). To meet these requirements, signal processing, data transmission, power supplies, and so on are carried out using nanotechnology, along with the help of VLSI (Very Large Scale Integration) design. Moreover, it has also been noticed that VLSI design using CMOS (Complementary Metal Oxide Semiconductor) by the means of ultraviolet lithography tends to attain the highest degree of accuracy.

Likewise, Very High Speed Integrated Circuit Hardware Description Language, also popularly known as VHDL, which is one of the most common integrated circuits (ICs) in the industry, can prove to be a great help in the implementation of designs and simulation of nanorobots to achieve even a higher level of accuracy and sensitivity.

Nanophotonic and nanotubes jointly may accelerate further the actual levels of resolution ranging from 248nm to 157nm devices in the assembly process of manufacturing of nanorobots in a CMOS industry.

Chemical Sensor

Nanowires[6] (Figure 1) have two quantum-controlled directions, in comparison to other low-dimensional systems, with one direction left unrestrained for the purpose of electrical conduction. As a result of this, nanowires can be used as nanoconductors for numerous nanodevice applications. Nanowires possess splendid properties for applications in various filed like that of excellent electrical, optical, mechanical, piezoelectrical, and field emission.

Nanowires, due to their spectacular properties, are capable of decreasing drastically the self-heating and thermal coupling for a CMOS when used as a suspended array in silicon circuits. Consequently, this provides maximum efficiency for applications regarding chemical changes, enabling new nanomedical applications. Therefore, more than half of the power supply in a nanorobot can be decreased by use of nanowires in their various circuits while manufacturing it.

Energy Supply

There can be a number of ways to supply energy to nanomachines from a human body itself. Inside a human body, temperature displacements can create potential differences, which can further be used as a voltage difference (Freitas, 1999).

The relation $E=hf$ can be well-used while using electromagnetic radiation, or light, where E is the energy generated by *photons,* depending on the frequency of light inside the body, f, encountering nanobots, and h is the Planck's constant ($=6.626 \times 10^{-34}$ Js). But these supplies of energy are not constant and may vary to a large extent. Thus, a wireless energy supply source may be used such as a microwave or a Radio Frequency wave generated from the patient's mobile phone to operate the transducers and *nanosensors* of nanobots efficiently inside a human body.

CURRENT DEVELOPMENTS IN NANOROBOTICS

Globally, several researches are being conducted in the field of nanorobotics in order to achieve the objective of synthesizing these miniature gadgets for human

Figure 1. SEM image of the zinc oxide (ZnO) nanowires grown by VLSI approach using Au catalyst (Courtesy: Liu, Wang, Kuo, Liang, and Chen (2007) "Recent Patents on Fabrication of nanowires")