NANITIES THE NANO-PIEZO ROBOTS

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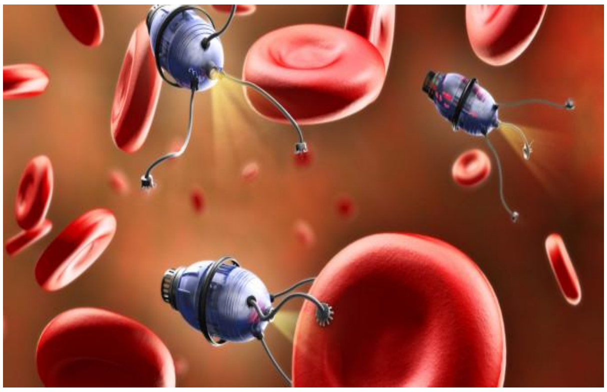
Abstract- A nanomachine, also called a nanite, is a mechanical or electromechanical device whose dimensions are measured in nanometers The first useful applications of nanomachines will likely be in medical technology, where they could be used to identify pathogens and toxins from samples of body fluid. Another potential application is the detection of toxic chemicals, and the measurement of their concentrations, in the environment.

I. INTRODUCTION

Nanotechnology is manipulation of matter on an atomic, molecular, and supramolecular scale. The earliest, widespread description of nanotechnology referred to the particular technological goal of precisely manipulating atoms and molecules for fabrication of macroscale products, also now referred to as molecular nanotechnology. A more generalized description of nanotechnology was subsequently established by the National Nanotechnology Initiative, which defines nanotechnology as the manipulation of matter with at least one dimension sized from 1 to 100 nanometers. Nanotechnology as defined by size is naturally very broad, including fields of science as diverse as surface science, organic chemistry, molecular biology, semiconductor physics, microfabrication, etc. The associated research and applications are equally diverse, ranging from extensions of conventional device physics to completely new approaches based upon molecular self-assembly, from developing new materials with dimensions on the nanoscale to direct control of matter on the atomic scale.



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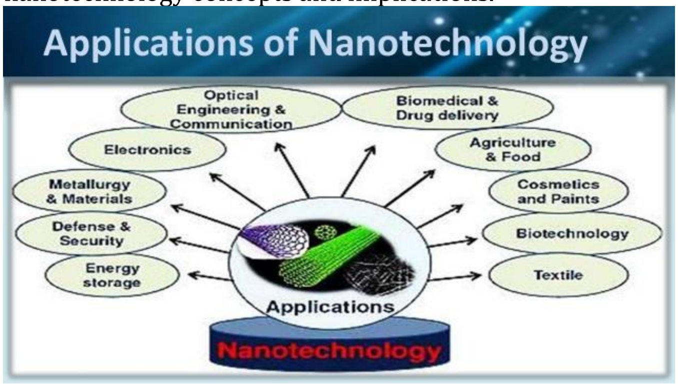
II. HISTORY

The concepts that seeded nanotechnology were first discussed in 1959 by renowned physicist Richard Feynman in his talk There's Plenty of Room at the Bottom, in which he described the possibility of synthesis via direct manipulation of atoms. The term "nano-technology" was first used by Norio Taniguchi in 1974, though it was not widely known.

Inspired by Feynman's concepts, K. Eric Drexler used the term "nanotechnology" in his 1986 book Engines of Creation: The Coming Era of Nanotechnology, which proposed the idea of a nanoscale "assembler" which would be able to build a copy of itself and of other items of arbitrary complexity with atomic control. Also in 1986, Drexler co-founded The Foresight Institute to help increase public awareness and understanding of nanotechnology concepts and implications.



Thus, emergence of nanotechnology as a field in the 1980s occurred through convergence of Drexler's theoretical and public work, which developed and popularized a conceptual framework for nanotechnology, and high-visibility experimental advances that drew additional wide-scale attention to the prospects of atomic control of matter. In the 1980s, two major breakthroughs sparked the growth of nanotechnology in modern era.

III. NANITIES

Nanotechnology also has a prominent role in the fast developing field of Tissue Engineering. When designing scaffolds, researchers attempt to the mimic the nanoscale features of a Cell's microenvironment to direct its differentiation down a suitable lineage. For example, when creating scaffolds to support the growth of bone, researchers may mimicosteoclast resorption pits.

Researchers have successfully used DNA origami-based nanobots capable of carrying out logic functions to achieve targeted drug delivery in cockroaches. It is said that the computational power of these nanobots can be scaled up to that of a Commodore 64.

Some nanoparticle products may have unintended consequences. Researchers have discovered that bacteriostatic silver nanoparticles used in socks to reduce foot odor are being released in the wash. These particles are then flushed into the waste water stream and may destroy bacteria which are critical components of natural ecosystems, farms, and waste treatment processes.

The microscopic size of nanomachines translates into high operational speed. This is a result of the natural tendency of all machines and systems to work faster as their size decreases. Nanomachines could be programmed to replicate themselves, or to work synergistically to build larger machines or to construct nanochips. Specialized nanomachines called nanorobots might be designed not only to diagnose, but to treat, disease conditions, perhaps by seeking out invading bacteria and viruses and destroying them.

Nanotechnology is the engineering of tiny machines — the projected ability to build things from the bottom up inside personal nanofactories (PNs), using techniques and tools being developed today to make complete, highly advanced products. Ultimately, nanotechnology will enable control of matter at the nanometer scale, using mechanochemistry. Shortly after this envisioned molecular machinery is created, it will result in a manufacturing revolution, probably causing severe disruption. It also has serious economic, social, environmental, and military implications

IV. WORKING

A. What is the Piezoelectric Effect?

Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. The word Piezoelectric is derived from the Greek piezein, which means to squeeze or press, and piezo, which is Greek for “push”.

One of the unique characteristics of the piezoelectric effect is that it is reversible, meaning that materials exhibiting the direct piezoelectric effect (the generation of electricity when stress is applied) also exhibit the converse piezoelectric effect (the generation of stress when an electric field is applied).

When piezoelectric material is placed under mechanical stress, a shifting of the positive and negative charge centers in the material takes place, which then results in an external electrical field. When reversed, an outer electrical field either stretches or compresses the piezoelectric material.

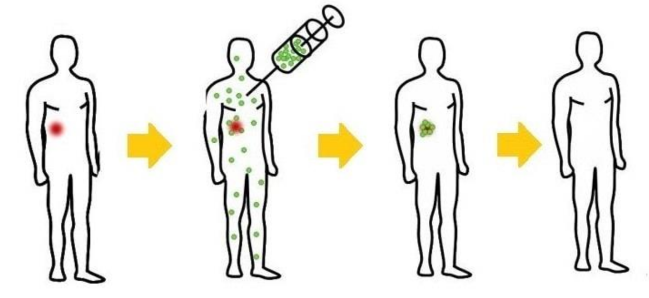
B. Piezoelectric Materials

There are many materials, both natural and man-made, that exhibit a range of piezoelectric effects. Some naturally piezoelectric occurring materials include Berlinite (structurally identical to quartz), cane sugar, quartz, Rochelle salt, topaz, tourmaline, and bone (dry bone exhibits some piezoelectric properties due to the apatite crystals, and the piezoelectric effect is generally thought to act as a biological force sensor). An example of man-made piezoelectric materials includes barium titanate and lead zirconate titanate.

In recent years, due to the growing environmental concern regarding toxicity in lead-containing devices and the RoHS directive followed within the European Union, there has been a push to develop lead free piezoelectric materials. To date, this initiative to develop new lead-free piezoelectric materials has resulted in a variety of new piezoelectric materials which are more environmentally safe.

C. Piezoelectric robots (Nanorobots)

Because very high voltages correspond to only tiny changes in the width of the crystal, this crystal width can be manipulated with better-than-micrometer precision, making piezo crystals an important tool for positioning objects with extreme accuracy, making them perfect for use in motors, such as the various motor series offered by Nanomotion.



Regarding piezoelectric motors, the piezoelectric element receives an electrical pulse, and then applies directional force to an opposing ceramic plate, causing it to move in the desired direction. Motion is generated when the piezoelectric element moves against a static platform (such as ceramic strips).

The characteristics of piezoelectric materials provided the perfect technology upon which Nanomotion developed our various lines of unique piezoelectric motors. Using patented piezoelectric technology, Nanomotion has designed various series of motors ranging in size from a single element (providing 0.4Kg of force) to an eight element motor (providing 3.2Kg of force). Nanomotion motors are capable of driving both linear and rotary stages, and have a wide dynamic range of speed, from several microns per second to 250mm/sec and can easily mount to traditional low friction stages or other devices. The operating characteristics of Nanomotion’s motors provide inherent braking and the ability to eliminate servo dither when in a static position.

D. Piezoelectric Materials

Piezoelectric materials are materials that can produce electricity due to mechanical stress, such as compression. These materials can also deform when voltage (electricity) is applied.

All piezoelectric materials are non-conductive in order for the piezoelectric effect to occur and work. They can be separated into two groups: crystals and ceramics.

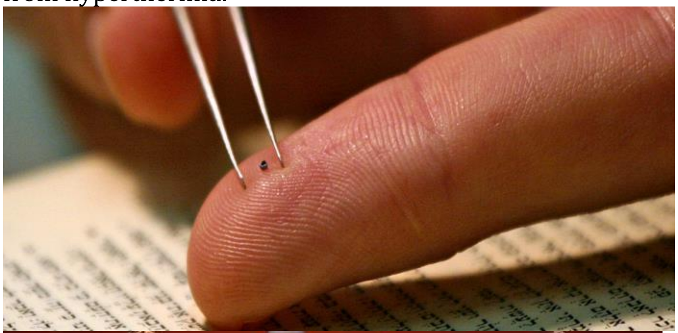
Some examples of piezoelectric materials are PZT (also known as lead zirconate titanate), barium titanate, and lithium niobate. These man-made materials have a more pronounced effect (better material to use) than quartz and other natural piezoelectric materials.

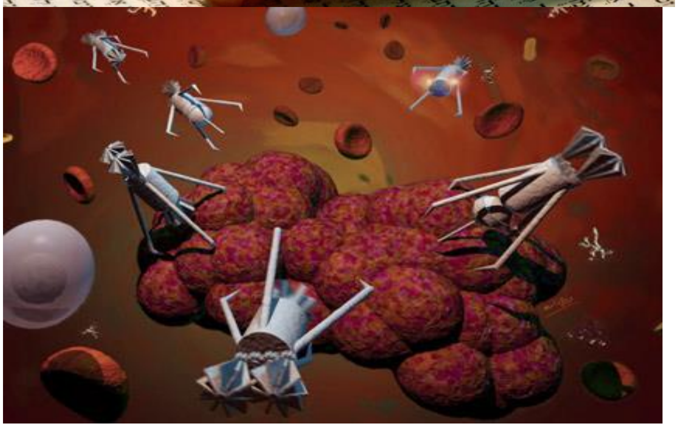
Compare PZT to quartz. PZT can produce more voltage for the same amount of applied mechanical stress. Conversely, applying voltage to PZT instead of quartz provides more movement. Quartz, a well-known piezoelectric material, is also the first known piezoelectric material.

PZT is created and produced (under high temperatures) with two chemical elements—lead and zirconium—and combined with a chemical compound called titanate. It is commonly used to produce ultrasounds transducers, ceramic capacitors, and other sensors and actuators. It also evinces a special range of different properties. In 1952, PZT was manufactured by Tokyo Institute of Technology.

V. RESEARCH ABOUT THE USES OF GOLD NANOPARTICLES

Nanotechnology researchers are looking into possibilities of using gold at the nanoscale to target drug deliveries, clean up the environment, and even treat persons suffering from hyperthermia.





Gold is an element used in jewelry, coins, dentistry, and electronic devices. Gold is even used in some medicines. Bulk gold is considered an inert material in that it doesn't corrode or tarnish. As with all metals, gold has good electrical and thermal conductivity. Gold's capability to resist corrosion as well as its high electrical conductivity make it useful for forming contacts in electronic devices.

Gold has been used in various medical treatments over the centuries without harmful effects. It was therefore natural for researchers to look to gold nanoparticles for medical applications rather than using elements such as platinum, which can be toxic in certain circumstances. Forming gold into nanoparticles allows researchers to use gold in areas that are too small for bulk gold to reach and brings with it new capabilities.

For targeted drug delivery uses, it will be interesting to see whether gold nanoparticles show any benefit versus cheaper types of nanoparticles, such as iron nanoparticles. For other uses, gold nanoparticles have some clear advantages.

When gold nanoparticles get really small, with a diameter of 5 nm or less, they can be used as a catalyst to help reactions that, for example, transform air pollutants into harmless molecules.

Using gold to clean up the air is somewhat surprising given that bulk gold is considered to be an inert material. Normally, gold would be a silly material to use as a catalyst for chemical reactions because it doesn't do much. However, if you break down gold to nanosize (approximately 5 nanometers), it can act as a catalyst that can do things such as oxidizing carbon monoxide.

Researchers attach molecules to gold nanoparticles that are attracted to diseased regions of the body, such as cancer tumors, and other molecules such as therapeutic drug molecules. This enables the functionalized gold nanoparticles to be used in targeted drug delivery.

Another property that gold nanoparticles have is the capability to convert certain wavelengths of light into heat. As with all metals, gold contains electrons that are not tied to a particular atom but free to move throughout the metal. These electrons help to conduct a current when a voltage is applied across the conductor. Depending on the size and shape of the nanoparticles, these free electrons will absorb the energy from a particular wavelength of light, at the right wavelength to make the cloud of free electrons on the surface of the gold nanoparticle resonate.

It turns out that two types of gold nanoparticle shapes are more efficient in converting light into heat:

- **Gold nanorods:** These solid cylinders of gold have a diameter as small as 10 nm. By using nanorods with different combinations of diameter and length, researchers can change the wavelength of light that the nanorod absorbs.
- **Nanospheres consist of a gold coating over a silica core:** By using nanospheres with variations in the thickness of the gold coating and the diameter of the silica core, researchers can change the wavelength of the light that the nanosphere absorbs.

Various researchers are using either nanorods or nanospheres to develop methods for localized heat treatment of diseased regions of the body. This method is called hyperthermia therapy.

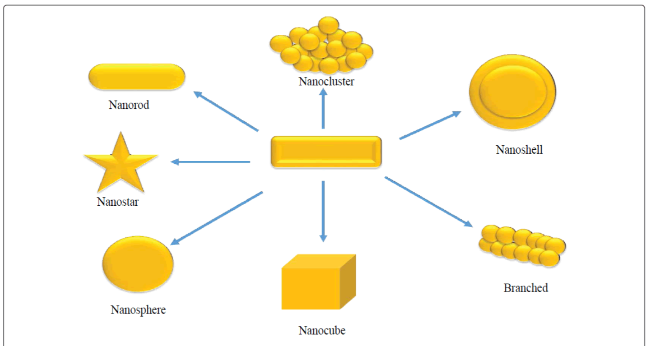


Figure 1: Various shapes of gold nanoparticles.

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