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Nanotechnology: Nanosensors

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***Abstract*- Nanosensors have widely emerged as a growing industry for development and innovations over the last decades. It has influenced all the strata's involving chemical, biological, electronics, and robotics, military, astronomical and environmental fields of interest. First synthetic Nanosensors were built by researchers at Georgia Institute of Technology in 1999. It basically have three method of construction: top-down lithography, bottom-up assembly, molecular self assembly including innovations: using semiconducting wires, material found in blue crabs, CNT's, photonic devices. They are built on nanoscale whose purpose is mainly to obtain data on atomic scale and transfer it into data easy to analyze. This has outreached great achievements by providing the world with great newer facilities as they are widely used in biological world for detecting cancers, asthma attacks, tumors, specific DNA in order to recognize explicit genetic defects, military applications, to detect minute quantities of explosives, bioagents, chemicals, toxins, and other dangerous materials in air and water, for assisting astronauts on space missions as their size and weight of the systems are constrained. Nanotechnology is the building field which has great potentials of innovations. Some of them under work and those which can be brought under vision in future are Graphene based gas sensors, cigarette smoke sensor, bomb detection, nanorobotics, aiding drug manufacturing by detecting minute flaws in drugs and improving its production, researchers has also developed new method to control nanoscale diamond sensors which allows to monitor small changes via magnetic field and neurons transmitted electrical signals. Key growth controllers of nanosensors are opportunity for improved sensitivity and ability to detect multiple chemical compounds concurrently. This field has a great vision for future development and enhancing technologies to a new level.**

***Keywords*- cancer, drugs, graphene, innovations, lithography, minute, nanorobotics, nanoscale, nanosensors, sensitivity**

I. INTRODUCTION

Nanosensors are more like other general purpose sensors with a varying characteristic of its small size and ability to detect minute particles or miniscule quantities of something. This technology works best without consumption of any time. As the size of the particles decreases the advancement increases exponentially. The materials on nanoscale, also known as nano materials whether biological or artificial, have unique and new properties that sometimes significantly differ from the materials on the macro scale. The key growth controllers of nanosensors are: the opportunity for improved sensitivity and ability to detect multiple compounds concurrently. Nanotechnology basically refers to a set of technologies which manipulate, produce and control materials within dimensions of 1nm to 100nm. In near future, nanosensors flawlessly communicate with the people and changing environment in an efficient way. They will give power to users and to scrutinize the environment around them in completely new ways, from analyzing air pollution, to gaining insight into biochemical traces and processes. Since the nano materials are relatively new, its market will be a research space. In this paper, the concepts used in nanosensors along with the improving technologies and the future scope of advancements are mentioned.

II. GROWING INDUSTRIES IN DIFFERENT STRATAS

2.1 Medical:

The healthcare and biomedical sector is the largest initial market for nanosensors owing to increasing requirement for rapid, compact, accurate, and portable diagnostic sensing system. Nanosensors are a new form of technology that will be able to monitor the build-up of bacteria on implants and warn clinicians when treatment is required before the problem escalates. The study is effective on nano scale and hence aids the manufacturing of drugs. Medical science holds various applications of nanosensors mentioned as detection of cancer, tumor, DNA monitoring, detection of bioagents and toxins in drugs etc.

2.2 Astronomical:

In the field of astronomy, nanosensors will yield the best results by reducing the size of the machines which presently occupies the space of a room. Researchers will use super-cooled atoms that are 10 million time colder than outer space to build sophisticated sensors which could revolutionize diagnostic medicine and need of aeronauts on spaceships and other navigation technologies. This will also focus on miniaturizing existing lab sensors to micro or nano chips, enhancing the development in the strata. Nano materials can

be useful in spacecrafts providing greater efficiency of the system.

2.3 Environmental:

Environmental safety can be improved by using nanosensors as check zones for a variety of polluting chemicals, ions, solid particulates, gases, as well as bio-molecules such as pathogenic microorganisms. However, mandatory regulatory tests for waste generating industries are promoting interest in nanosensors to test environmental samples and continuous improvement in nanosensors design.

2.4 Military:

Security is the most important prospect for everyone. In military applications, chemical nanosensors and nanobiosensors are considerable as security surveillance devices in detection of potential harmful explosives, biological warfare agents and chemicals. Military appliances for various testing and decoding can also be aided using nanosensors and injecting the system with the technology to make it more efficient. Bomb detection, hidden chemical explosives, and any other unusual and dangerous thing can be detected and will be useful for the strata's development and efficiency.

2.5 Electronical:

Electronic hub is working fully on VLSI technologies in present system and seems to dissolve the system even to more composite system. Nanosensors hold a great revolution in the strata. The concept of internet of things and robotics is all based on nanotechnology for improvement scope in future. Internet of things is a concept purely based on sensors and things connectivity around us, thus nanosensors will be building block for the same providing sustainability to the framework. Nanorobotics holds a big market for improvement enhancing the applications of nanosensors.

III. FUTURE ADVANCEMENTS IN METHOD OF CONSTRUCTIONS:

The basic methods of construction may include top-down lithography, bottom-up assembly, molecular self-assembly using semiconducting wires, CNT's, photonic devices etc. Apart from these various future evolutions may take form as follows:

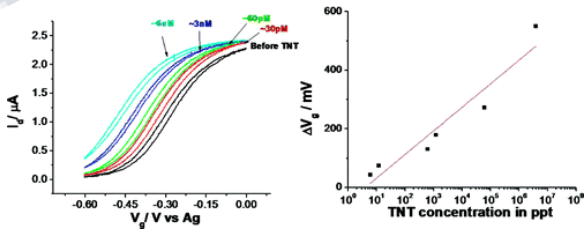
3.1 Graphene-based nanosensors:

Graphene nanosensors can be used for affinity based detection of low charge, low molecular weight molecules. The sensor is capable of measuring glucose concentration in a particularly relevant range of 2 micrometer to 25 millimeter. Biotransferrable Graphene wireless nanosensors can be produced. For this, Graphene is printed onto bioresorbable silk and contacts are formed containing a wireless coil. This architecture is then transferred on the area of application, where it senses the changes and transfers the signal through wireless coil.

Failure behavior of Graphene based pressure sensor can be studied. This sensor is made of a Graphene nanoflake suspended over a well in a silicon carbide substrate and clamped on its surrounding edge by covalent bonds. Failures are characterized by complete detachment of Graphene nanoflake from the silicon carbide substrate or by rupture of the Graphene nanoflake.

3.2 Vapour sensor:

Real-time detection of trace chemicals, such as explosives, in a complex environment containing various interferents has been a difficult challenge. We describe here a hybrid nanosensors based on the electrochemical reduction of TNT and the interaction of the reduction products with conducting polymer nano junctions in an ionic liquid. The sensor simultaneously measures the electrochemical current from the reduction of TNT and the conductance change of the polymer nano junction caused from the reduction product. The hybrid detection mechanism, together with the unique selective pre-concentration capability of the ionic liquid, provides a selective, fast, and sensitive detection of TNT. The sensor, in its current form, is capable of detecting parts-per-trillion level TNT in the presence of various interferents within a few minutes.



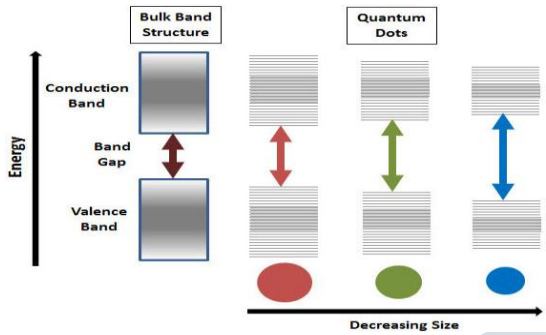
3.3 Mimic Human cell:

Constructing a sensor using nanotechnology to mimic human immune cells that circulate around the body, indicating when something is wrong and responding positively to any problems that surface may be possible one day in future, but for now, it remains a big step to take. This can be done by tracing the functions of various cells and making a nanosensor along with quantum dot concept which can detect any minor unusual characteristic interior to body.

3.4 From materials found in crab:

Blue crab contains a material chitosan which have some electrical properties. These materials are coated on the nano sensing device to facilitate the detection process. According to the processes and detection generated through sensors, signals are sending to the external system which shows the change in the properties of the materials found in the shell of blue crab and hence indicates various aspects like can be used for detection of impurities in the drugs; detect minute quantities of explosives etc.

3.5 Quantum dots:



Quantum dots are tiny particles or nanocrystals of a semiconducting material with diameter in the range of 2-10 nanometers. Its properties lie between those of bulk semiconductors or discrete molecules. As they have small size, quantum dots are confined in quantum box. Now, the size of the nanomaterial is manipulated and the sensor detects the change in colour occur due to the phenomenon, with the decrease in size, the difference between energy levels increases and hence more energy will be required for excitation and therefore for coming back to ground, indicated by change in colour.

IV. WORKING OF NANOSENSORS:

The basic working principle of the nanosensors involves the method of preparation of the sensors and then synthesizing the properties according to the functioning required. The sensor is then implanted on the device, from where it detects the variations (in form of vibrations, colour change, heat generation, or other chemical or electrical changes). These variations are received by an external system which calculated the vibrations and changes and helps identifying the required data. These sensors mainly aim in monitoring electrical changes in the sensor materials. By treating the nanotubes with various coating materials, they can be made sensitive to certain molecules and immune to others.
For instance, if a nanotube is coated with NO2, it will strip electron from nanotubes and indicate its reaction with the system. On similar grounds if they are coated with NO3, they will donate electron to it. On this ground various conclusions can be drawn.

V. APPLICATIONS:

Nanotechnology is a field with wide ranging applications whether it is in research or base for any new technology. Some of the applications can be grouped as:

- Detect various chemicals in gases for pollution monitoring.
- As blood borne sensors or in lab-on-a-chip type device.
- To monitor parameters as temperature, displacement, and flow.
- As accelerometers in MEMS devices like airbag sensors.

Various other important applications which brought the revolution and even hold the chances for future development are as follows:

5.1 Cancer Detection and Treatment:

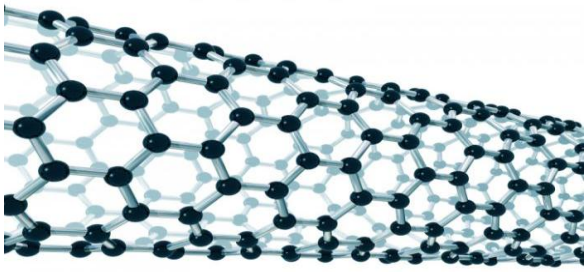
Nanotechnology has the potential to detect and kill the early cancer cells. Many patients have already received chemotherapy by nanosensors called liposome. Within few years, with introduction of more technologies our body's biggest defenders may be tinier than we could have ever imagined. This technology is incomparable to any other. Researchers have designed nanosensors which returns a massively amplified, whopping signal when they bind to cancer cells in colon and further work is headed on to trigger the self-assembly of nano-particles when they enter a cancer cell.

By changing the size of particles, tuning can be done to make nanosensors behave in specific way. Likewise here, grabbing onto and then releasing cancer cells can be used for study. Some can absorb light and vibrate to show the presence of tumor or to release heat to kill the cells from inside. Recently, progress is under taken on technology for use outside the body to identify and characterize tumor cells present at miniscule levels in all manner of bodily fluid tracing a course of a known disease long before symptoms arise. Future advancements in nanotechnology in cancer detections aids the eye to magnetic shifter, silicon based chip and gold-silica nanosensors sort of technical hand.

5.2 Aiding drug Manufacturing:

Nanosensors are made from carbon nanotubes, each about 1 lakh times smaller than a strand of hair. Speeding up and increasing sensitivity of the process of diagnosis is a major focus for research. Nanotechnology holds a great scope

in medicine as small size allows penetrating cells, getting inside cells and manipulating their functions. Drugs and antibodies won't penetrate these biofilms prepared as nanosensors, so the only thing to do is just to operate and remove that biofilms almost by hand by scooping it out of the tissue. Strong precision is achieved and errors can be resolved to major extent via nano-particles scale monitoring.



5.3 Security:

Nanosensors are very helpful for detecting dangerous substances, tiny amount of explosives or chemicals, which could save many lives in future.

Animal cells can also be applied to the technology for improvement. These cells can be used for detection of dangerous substances. Nanosensors contain multiple vibrating cantilevers coated with substances from animal shell. The changing of cantilevers will help find different substances having different concentration. When any particle enters the device from air the substance on specific cantilever will interact and make it vibrating. This vibration is indicated in optical sensing system which shows the detection of substance.

Example: chitosan, a substance found in crab shell is used for detection in many areas.

VI. CONCLUSION:

With the development comes the boost in the advancement of the technologies. Nanotechnology is a wide area for development in future and holds minimum cons in its pocket. It offers an exquisite sensitivity and precision that is difficult to match with any other technology. Due to advancements in above, development is possible in all fields whether it be biological, chemical, astronomical, medical or research. Moreover alongside pays hand to other growing technologies and stratas like internet of things industry, etc. molecules on the nano meter scale operate in a dusky netherworld where the laws of physics wobble at the edge of quantum galaxy. So with the decrease in size, increase in opportunities is created. This is an evolution in terms of technological level as it changes the living environment around us. From the paper, note should made on the emphasis paid on the developmental innovations and the achievements in the field of nanotechnology, specifically using nanosensors. From a practical perspective, nano-based techniques aren't the wave of the future. This is the now.

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