Advancements in Micro-Nano-Mechatronics sensors controller and actuators

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ABSTRACT

The study of the behavior of materials and devices at micro and nano-scales, the Micro & Nano-Mechatronics research group designs solutions around the unequalled opportunities offered at those scales. The research opportunities are boundless, ranging from scientific research into theoretical foundations for the behavior of materials to devising micro and nano-fabrication techniques and finally device design and characterization. It basic molecular structure principals of Nano-materials. It will address the molecular structures of various materials. The long term goal design of materials for a broad range of applications. Our goals in the design of materials, devices or systems are a combination of improving performance, miniaturization, lowering power consumption, reducing cost and waste and making flexible transducers and electronics. Micro and Nano Mechatronics is the synergistic integration of micro and nano electromechanical systems and electronic technologies, with high added value. Strong research efforts are being focused on development of organic combinations of multiple miniaturized actuators and sensors to perform complex motions and operations. Micro/nano technologies, as very important technologies for future robotics and automation, are becoming crucial to realizing high performance systems. Our research group has direct access to state-of-the-art facilities for fabrication and characterization of micro and nano-devices.

Keyword: - *semiconductor, Metal-and carbon-based nano structures, sensors controller and actuators*

1. Introduction

Micro-Nano-mechaTronics is currently used in broader spectra, ranging from basic applications in robotics, actuators, sensors, semiconductors, automobiles, and machine tools. As a strategic technology highlighting the 21st century, this technology is extended to new applications in bio-medical systems and life science, construction machines, and aerospace equipment, welfare/human life engineering, and other brand new scopes.

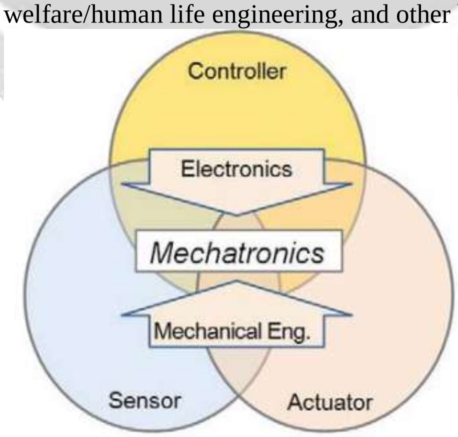


Fig-1 Mechatronics circular form

Basically, the miniaturizing technology is important to realize high performance, low energy consumption, low cost performance, small space instrumentation, light-weight, and so on. High efficiency High integration, High functionality, Low energy consumption, low cost, Miniature, etc. we using Micro-Nano-MechaTronics technology

2. Application of Micro-Nano-MechaTronics Sensors

Many nanosensors are using in materials, physical, chemical, and biological, optical, electronics, semiconductor, machine design, machine tool, automobiles and aerospace etc Nanomaterials describe, in principle, materials of which a single unit is sized (in at least one dimension) between 1 to 1000 nanometres(10^{-9} meter) but usually is 1 to 100 nm (the usual definition of nanoscale[1]). Nanomaterials research takes a materials science-based approach to nanotechnology. Nanomaterials-based sensors have several benefits in sensitivity and specificity over sensors made from traditional materials. Nanosensors can operate at a similar scale as natural biological processes, allowing functionalization with chemical and biological molecules, with recognition events that cause detectable physical changes. Nanophotonics or nano-optics is the study of the behavior of light on the nanometer scale, and of the interaction of nanometer-scale objects with light. It is a branch of optics, optical engineering, electrical engineering, and nanotechnology.

The term "nano-optics", just like the term "optics", usually refers to situations involving ultraviolet, visible, and near-infrared light (free-space wavelengths from 300 to 1200 nanometers).

Nanoelectronics refer to the use of nanotechnology in electronic components. The term covers a diverse set of devices and materials, with the common characteristic that they are so small that inter-atomic interactions and quantum mechanical properties need to be studied extensively.

Nanotechnology-enabled sensors are providing new solutions in physical, chemical, and biological sensing that enable increased detection sensitivity, specificity, multiplexing capability, and portability for a wide variety of health, safety, and environmental assessments. The Sensors NSI addresses both the opportunity of using nanotechnology to advance sensor development and the challenges of developing sensors to keep pace with the increasingly widespread use of engineered nanomaterials.

NNI agencies participating in the Sensors NSI coordinate efforts and stimulate existing and emerging projects to explore the use of nanotechnology for the development and commercialization of nanosensors. Agency representatives hold periodic teleconferences to address pressing technical questions and keep each other informed of ongoing and planned activities of mutual interest. These regular exchanges have led to tangible results such as revised solicitations based on the knowledge of other agencies' priorities, needs, and plans; cross-agency participation in review of proposals and grantee meetings; and the identification of collaborators for specific project needs. In addition, the ongoing research dialogues inform agency members of opportunities for collaboration in the formulation of both agency-specific and joint funding announcements that support the overall goals of the initiative.

An important priority remains engaging with stakeholders to identify the barriers they face in the development and commercialization of nanosensors. The Sensors NSI serves as a focal point for relevant stakeholder communities and the public to address opportunities and barriers through the Request for Information (RFI) mechanism, town hall discussions, and community meetings. Common themes continue to be identified through these inputs and interactions. For example, the needs for improved stakeholder awareness, communication, and collaboration at the convergence of testing and operational standards, and for access to test and fabrication facilities, have been particularly highlighted in the stakeholder interaction activities of the Sensors NSI.

With support from NNCO, the feedback from the aforementioned community-building efforts was used in the planning for the Sensor Fabrication, Integration, and Commercialization Workshop held September 11–12, 2014. This event focused on identifying key challenges faced by sensor developers and on determining the critical needs of the community, especially with respect to necessary standards, testing facilities, and advances in manufacturing. Several key outcomes from this workshop will inform the path forward for the signature initiative. One area discussed was the critical need to access test conditions beyond standard laboratory environments. Realistic test beds are essential for the relevant and reliable transition of prototype sensors from research to commercial use. Sensor developers also expressed the need for access to fabrication facilities beyond the prototype stage, but prior to large-scale production, to demonstrate performance characteristics, reproducibility, and other measures required for adoption. Support for enhanced communication and a desire to share best practices were also strongly expressed by the community. In response to this and other feedback, the Sensors NSI page has been revised to more effectively serve as a portal for information and guidance to the nanosensor development community regarding sensor fabrication and test facilities, funding opportunities, regulatory information, standards, and other relevant resources. The Sensors NSI will continue to work and engage with community leaders to improve this portal and explore opportunities and forums to facilitate communication and collaboration in the quest to accelerate sensor development.

2.1 Nanosensors

A substance found in the shell, called chitosan, is a key component used in a nanosensor, a "system on a chip" at the nanoscaleν Detects minute quantities of explosives, bioagents, chemicals, and other dangerous materials in air and waterν This could lead to security and safety developments for airports, hospitals,ν etc. The chitosanν is a biological compound that readily binds to negatively charged surfacesν Multiple mini vibrating cantilevers, which resemble diving boards, are coated with the chitosanν Optical sensing technology is used to see when the cantilevers vibrations changeν Different cantilevers detect different substances and concentrationsν When the targeted substance enters the device from the air/water,the chitosan on a specific cantilever interacts with the substance and causes that cantilever's vibration to change The optical sensing system sees the vibration change and indicates that the substance has been detected.

2.2 Electrometer: consists of a torsional mechanical resonator, a detection electrode, and a gate electrode used to couple charge to the mechanical element .Chemical Sensor: incorporates capacitiveν readout cantilevers and electronics for signal analysis and sensitive enough to detect single chemical and biological molecules

Application Transportation Communications Integrated Circuits Building and Facilities Medicine Safety Aerospace. In the future could lead to tiny, low power, smartν sensors manufactured cheaply in large quantities Service areas could include: Sensing of structural materialsν Sensor redundancy in systemsν Size and weight constrained structures.

2.3 Actuators

The exceptional electrical and mechanical properties of carbonν nanotubes have made them alternatives to the traditional electrical actuators for both microscopic and macroscopic applications. Carbon nanotubes are very good conductors of both electricity and heat, and they are also very strong and elastic molecules in certain directions. These properties are difficult to find in the same material and very needed for high performance actuators. For current carbon nanotube actuators, multi-walled carbon nanotubes (MWNTs) and bundles of MWNTs have been widely used mostly due to the easiness of handling and robustness. Solution dispersed thick films and highly ordered transparent films of carbon nanotubes have been used for the macroscopic applications.

Carbon nanotube tweezers have been fabricated by deposition ofν MWNT bundles on isolated electrodes deposited on tempered glass micropipettes. Those nanotube budles can be mechanically manipulated by electricity and can be used to manipulate and transfer micro- and nano-structures. The nanotube bundles used for tweezers are about 50 nm in diameter and 2 μm in lengths. Under electric bias, two close sets of bundles are attracted and can be used as nanoscale tweezers.

2.4 Carbon nano-heat engine

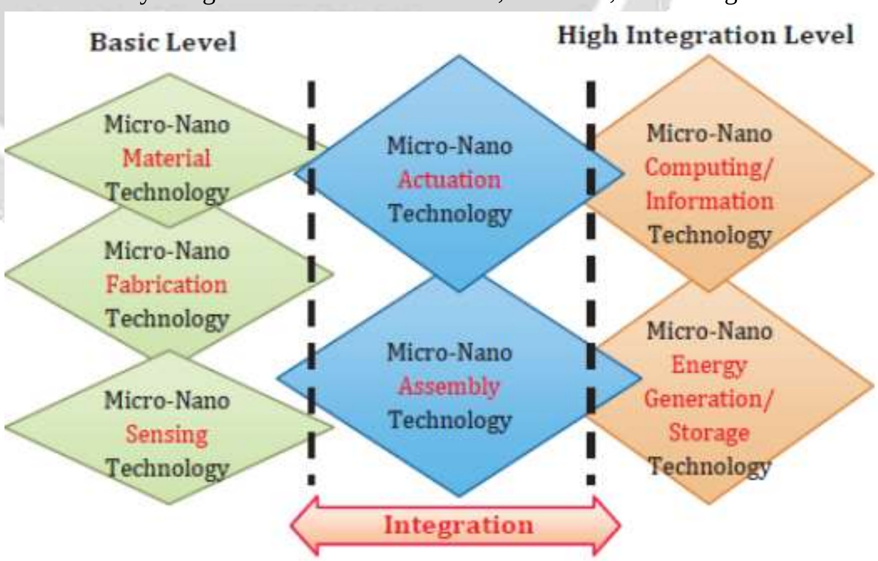
A research group in Shanghai University led by tienchong Changν have found a dominoes like motion in carbon nanotube which can be reversed translating direction when apply different temperatures. This phenomenon make it possible to use carbon nanotubes as a heat engine working between two heat source.

Microscopic applicationsν Nanotube on/off switches and random access memory Harvard researchers have used the electrostatic attraction principle to design on/off switches for their proposed nanotube Random Access Memory devices. They used carbon nanotube bundles of ~50 nm in diameter to fabricate their proof-of-concept prototypes. One set of MWNT bundles are laid on the substrate and another setν of bundles is trenched on top of the underlying nanotube bundles with air gap in between. Once electrical bias is applied the sets of nanotube bundles are attracted, thus changing the electrical resistance. These two states of resistance are on and off states. They have managed to get more than 10 times difference between off and on state resistances. This idea can be used as very highly packed arrays of nanoswitches and random access memory deivces if they can be applied to arrays of single-walled carbon nanotubes, which are about 1 nm in diameter and hundreds of micrometres in length. The current technical challenge with this design is the lack of control to place arrays of carbon nanotubes on substrate.

Nanotube sheet electrodes could be used as actuators artificial muscles and giant strokes byν MWNT aerogel sheets Nanotube-based transistors, also known as carbon nanotube field-effect transistorsν (CNTFETs), have been made that operate at room temperature and that are capable of digital switching using a single electron. However, one major obstacle to realization of nanotubes has been the lack of technology for mass production. In 2001 IBM researchers demonstrated how metallic nanotubes can be destroyed, leaving semiconducting ones behind for use as transistors. Their process is called "constructive destruction," which includes the automatic destruction of defective nanotubes on the wafer.This process, however, only gives control over the electrical properties on a statistical scale. The first nanotube integrated memory circuit was made in 2004. One of the main challenges has been regulating the conductivity of nanotubes. Depending on subtle surface features a nanotube may act as a plain conductor or as a semiconductor. A fully automated method has however been developed to remove non-semiconductor tubes.ν Another way to make carbon nanotube transistors has been to use random networks of them. By doing so one averages all of their electrical differences and one can produce devices in large scale at the wafer level.This approach was first patented by Nanomix Inc. It was first published in the academic literature by the United States Naval Research Laboratory in 2003 through independent research work. This approach also enabled Nanomix to make the first transistor on a flexible and transparent substrate.

Future applications As a result, carbon nanotubes have been shown to be great materials for actuation related applications. The subfield of carbon nanotube actuators have been quite successful and ready for scalable applications considering there are quite a few conventional and scalable methods for the synthesis of large scale carbon nanotubes. Carbon nanotube sheets used as electrodes in electrolyte solutions offered low voltage operations at room temperature with actuation strokes and rates comparable to the conducting polymer actuators, but with higher work densities per cycle and life times. However the actuation strokes are much smaller than those of the electrostrictive rubbers which operate at three orders of magnitude higher voltages. On the other hand, realization of carbon nanotube aerogels made giant strokes possible comparable to electrostrictive rubbers at room temperature, but carbon nanotube aerogels can perform at a very wide range of temperatures, and with very high actuation rates, which are even better than the actuation rate of the human muscles.

The applications of nano mechatronics are mainly categorized into the mechanical, electrical, and biological/medical applications The key point for the categorization is inorganic (wet) and organic (dry) mechanical applications are relatively based on thinorganic materials or technologies, such as lithography technique On the other hand, biological/medical applications, the organic materials or technologies are used, such as self- assembly technique in between them, electrical applications are placed for delivering orcalculating information and so onν Since the nanomechatronics is the composite academic fields, the required technologies are mainly categorized in to basic/middle/high integration levels.



3. CONCLUSIONS

Basically, nanotechnology is placed in the combinations of the top-down and bottom-up approaches. The possibility to control the structure of matter atom by atom was first discussed by Richard Feynman in 1959 seriously. One of the approaches to fill the gap between top-down and bottom-up approaches is “nanomanipulation”, which realizes controlling the position at the nanometer scale, is considered to be one of the promising ways. The top-down fabrication process, or micromachining, provides numbers of nanometer structures at once. On the other hand, the bottomup fabrication process, or chemical synthesis such as self-assembly, also provides numerous nanometer structures. In fact, both approaches reach nanometer scale with the limitations of physical/chemical aspects at present. Hence, the technology to fill its gap is considered to be one of the important at this moment for nanomechatronics. Especially, current research directions are mainly two flows, “green innovation” and “life innovation”. These innovations will be achieved in various research and developments.

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BIOGRAPHIES

Prem Pratap Singh Bhati received his M.Tech. Degree in Power Systems Engineering (in 2015) from Marwar Engineering College & Research Center, Jodhpur and belong to Rajasthan technical university, kota in India. Currently working as Assistant Professor in the Department of Electrical Engineering, Aryabhatta College of Engineering and Research Centre, Ajmer, Rajasthan in India. His areas of research include Mechatronics ,power system transient stability, power system dynamic stability, FACTS, Neural Network, fuzzy logic.