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Aspects and Applications of Nanotechnology and the new trends of Nanomanufacturing

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Introduction

Nanotechnology is recognized as a promising new growth innovator for the decades to come. It is generally evolved in information concentrated associations (eg, Universities or Company R&D research facilities) unequivocally centered around the science and innovation part of nanotechnology. Science and innovation are viewed as significant determinants for endurance and development of organizations, districts and countries and are connected with new speculations of monetary turn of events, mechanical change and modern advancement. To arrive at innovation based financial development, it isn't simply important to contribute capital, astuteness and time in science and innovation related innovative work (R&D), yet additionally to execute pressures connected with dispersion, reception and execution of innovation based advancements. Also, troublesome advancements as the partner of advances with a steady development impact - structure significant basics for development developments and related abundance creation.

Anyway according to the development viewpoint it is essential to work with the capacity to take advantage of the imaginative and added worth of nanotechnology into applications. This implies that nanotechnology information created in information escalated associations should be changed or potentially moved to configuration, produce, sell, take on and execute nanotechnology-based client arranged applications. The advancement improvement process are authoritative level from R&D to creation to advertise prepared applications isn't direct, yet a cyclic interaction with equal and iterative circles. Concerning problematic advances like nanotechnology, Walsh, 2004 presents a framework model that brings up the elements between innovation push side and market pull side in the development improvement process. Nanotechnology as troublesome innovation can prompt future (at first obscure) markets. This gives extra aspects and difficulties to creative cycles covering advancement and commercialization of nanotechnology in a worldwide market field, particularly for little nanotechnology firms.

The explanation that nanotechnology is so fascinating is that materials at the nanoscale have totally unexpected properties in comparison to materials on the macroscale. The physical, synthetic and organic properties in general and cycles we know about on sizes of perception inside everyday human insight might be on a very basic level distinctive on the nanoscale: conductivity of hotness and power, attractive properties, optical properties, actual strength of materials, reactivity and response rates. This has opened up altogether new lines of examination to comprehend the events, piece and design, of nanoparticles and the central rules that control synthetic, physical and natural cycles on the nanoscale.

A New Kind of Science

In a visionary talk to the American Physical Society at Caltech in 1959, Richard Feynman outlined an entirely new type of science in a talk There's Plenty of Room at the Bottom (pdf): "What I want to talk about is the problem of manipulating and controlling things on a small scale....I don't know how to do this on a small scale in a practical way, but I do know that computing machines are very large; they fill rooms. Why can't we make them very small, make them of little wires, little elements, and by little, I mean little?" (See the YouTube video Tiny Machines given by Dr. Feynman in 1984 at the Esalen Institute). A revolution was started. We now have the analytical tools needed to observe and characterize, theory and computational models

to explain, and the ability to engineer and manufacture new types of materials on the nanoscale that have begun to realize Richard Feynman's vision. These are the foundations of nanoscience and nanotechnology.

Classical models of the properties of materials applied at the macroscale break down for very small nanoscale particles. The "rules" are different at the nanoscale:

Materials (of the same composition and structure) may exhibit completely different properties for macro- v. nanoscale particles. The figure on the right shows how color varies for CdSe particles in suspension as a function of their particle size.
At the nanoscale, surface areas (and therefore, surface energies) tend to be relatively large with respect to particle volume. Surface energies are usually ignored in classical thermodynamics (relative to Gibbs Free Energy), but may have a significant influence on reactivities and reaction rates at the nanoscale.

At the nanoscale, inter-atomic forces often dominate materials, and therefore, applications of quantum mechanics (don't panic!) becomes the most important approach for interpreting and explaining material properties.

The chemical environment on the nanoscale may be very different than the bulk chemical environment on the macroscale; the interfaces across boundaries between a nanoparticle (or even a living cell) and an ambient environment may very locally establish chemical potential gradients that influence nucleation, growth, and reaction rates that do not represent the physico-chemical conditions of the bulk system.

Number of atoms vs. percentage of surface atoms, assuming a closest-packed structure. Image by Michael Hochella, Virginia Tech, NanoEarth project.[creative commons]Nanoscience also addresses one of NSF's "10 Big Ideas: "Growing Convergent Research". Convergence research is a means of solving vexing research problems, in particular, complex problems focusing on societal needs. It entails integrating knowledge, methods, and expertise from different disciplines and forming novel frameworks to catalyze scientific discovery and innovation. NSF identifies Convergence Research as having two primary characteristics:

Research driven by a specific and compelling problem. Convergence Research is generally inspired by the need to address a specific challenge or opportunity, whether it arises from deep scientific questions or pressing societal needs.

Deep integration across disciplines. As experts from different disciplines pursue common research challenges, their knowledge, theories, methods, data, research communities and languages become increasingly intermingled or integrated. New frameworks, paradigms or even disciplines can form sustained interactions across multiple communities.

Dimensions of Nanotechnology/Science Research

- Nanoscience explores the fundamental properties of matter in 1, 2, and 3 dimensions. It is primarily focused on changes with variation of size and dimension of particles on the nanoscale.

- Nanotechnology is focused on manipulating matter on the nanoscale (nano-particles, rods, sheets, thin film coatings) to exploit changes in physical properties to create materials that will be beneficial to society.

- Advances in nanoscience and nanotechnology require observations and measurements of chemical, electrical and mechanical properties on the nanoscale.

Characterization of nanoparticles

The composition, atomic structure, size and shape, and surface properties all contribute to the physical, chemical and biological properties expressed by particles on the nanoscale. We now have an arsenal of analytical methods that allow us to observe materials down to the atomic scale: TEM, FE-SEM, AFM, XRD, and many more. Computational and theoretical approaches also contribute to the characterization of nanoparticles and predicting their behaviors.

Nanomanufacturing

Whole new classes of materials are being designed and developed using the remarkable properties being discovered in nanoparticles. "Nanotechnology is helping to considerably improve, even revolutionize, many technology and industry sectors: information technology, homeland security, medicine, transportation, energy, food safety, and environmental science, and among many others" (see Benefits and Applications from the National Nanotechnology Initiative.

Discovery of nanoparticles in natural systems. What are their composition and structure? What are their occurrences? How do these affect reactivities, reaction rates, energy and mass balance in natural systems? How are nanoparticles related to biological systems, as products of biogenic processes, or in their ability to influence biological (e.g., metabolic) functions? How do these impact global biogeochemical cycling. The role of nanoparticles, whether natural or introduced as anthropogenic materials, in the Earth system are largely unknown. "You can see a lot just by looking" (attributed to that great 20th Century philosopher, Yogi Berra). There is a great need to systematically survey and inventory the types of nanoparticles that abound in the solid Earth, soils, natural waters, and atmosphere.

Various aspects of Nanotechnology

Nanotechnology and dynamic international market manipulating atoms arrangements is the basis of nanotechnology and ideas in this field were first communicated by physicist Feyman (1959). Nanotechnology as per Roco 1999 is worried about advancement and use of constructions and gadgets with authoritative elements at the quick scale between individual atoms and around 100 nanometers where novel properties happen when contrasted with mass materials. These nanoscale designs and gadgets might have extraordinary compound, electrical, attractive, optical or organic properties. At the intersection of Chemistry, Physics, Biology, Computer Science and Engineering, Nanotechnology inserts nanoscience knowledge to create new materials, designs or gadgets which takes advantage of nanoscale properties. The idea of nanotechnology is solid multidisciplinary and Hullman and Meyer (2003) show this by means of the scope of logical disciplines nanotechnology distributions and nanotechnology patent covers. Some discipline models for example are material science, polymer science, electrical and electronic designing, Optics, biophysics, natural science or cell science. The patent information recommends that the center exercises of nanotechnology center around hardware, instrumentation, and synthetic compounds/drugs. Other than this end dependent on patent information, Bhat 2003 sees the accompanying enterprises liable to be promptly affectedbynanotechnology,aerospace,automotive,biotechnology,ceramics,chemicals, registering, guard, gadgets, metals, materials, paper, plastics, environmentally friendly power, materials and broadcast communications.

Nanotechnology as a bunch of new innovations goes through commonplace examples of logical, mechanical and monetary turns of events. First nanoscience has lead to a solid logical push and brought about an emotional increment of logical distributions and licenses on nanotechnology. (Compano and Hullmann, 2002; Hullman and Meyer, 2003; Marinova and McAleer, 2003; Roco, 2003). Also, the innovation pull has arisen to utilize and change nanoscience to utilize and change nanoscience information into advancements. Of late an untimely market-pull time has been started which invigorates the utilization of nanotechnology in applications to make developments. In this stage, organizations are really creating and selling nanotechnology based applications. Then again, Mazzola 2003, brings up that numerous nanotechnology applications are currently at idea level, requiring significantly more essential examination before they can be consolidated into practical applications. Connected with the regular; Sigmoidal bend of development dissemination (Rogers,1995) nanotechnology is just about in the purported "take-off stage".

New trends of Nanomanufacturing

Transforming the guarantee of nanoscience into new innovations is probably the greatest test that face the exploration local area today. The bottleneck is the absence of advancements for assembling nanostructures and nanomaterials in huge amount and for minimal price. Research in nanomanufacturing is centered around creating optical based, minimal expense, greatly equal assembling methods. In particular, a kind of nanostructure, called nanoscale optical recieving wire is created to focus energy of light into a nanoscale space, and is being utilized for nanomanufacturing reason. This includes explores in a few disciplines, including producing Science and designing, control, radiation, optics and mechanics. Nanomanufacturing is both the development of nanoscaled

materials, which can be powders or liquids, and the assembling of parts "base up" from nanoscaled materials or "top down" in littlest strides for high accuracy, utilized in a few advances like laser removal, carving and others. Nanomanufacturing includes increased, solid and practical assembling of nanoscale materials, constructions, gadgets and frameworks. It additionally incorporates exploration, improvement, and mix of top down processes and progressively complex base up or self get together cycles.

Inside the hierarchical and base up classifications of nanomanufacturing, there are developing number of new procecesses that empower fabricating. Among these are:- Chemical fume statement is a cycle where synthetic compounds respond to deliver extremely unadulterated, superior execution films.; Molecular Beam Epitaxy - is one technique for storing exceptionally controlled slender movies.; Atomic layer epitaxy-is an interaction for saving one iota thick layers on a surface.; Dip pen lithography-is a cycle wherein the tip of a nuclear power magnifying lens is "plunged" into a substance liquid and afterward used to "compose " on a surface, similar to an antiquated ink pen into paper.; Nanoimprint lithography-is a cycle for making nanoscale highlights by "stepping" or "printing "them on to a surface.; Roll-to-move handling is a high volume interaction to create nanoscale gadgets on a roll of ultrathin plastic or metal.; Self-gathering depicts the interaction where a gathering parts meet up to frame an arranged construction without outside bearing. Constructions and properties of materials can be worked on through these assembling processes. Such nanomaterials can be more grounded, lighter, more strong, water repellent, hostile to intelligent, self cleaning, bright or infrared safe, antifog, antimicrobial, scratch safe or electrically favorable among different qualities. Exploiting these properties, the present nanotechnology empowered items range from b-ball bats and tennis rackets to impetuses for refining unrefined petroleum and ultrasensitive location and ID of natural and synthetic poisons. Despite the fact that enterprises and applications are or will be affected by nanotechnology, Bhat 2003 contends that the referenced multidisciplinary nature of nanotechnology makes it undeniably challenging to nail down and prophery the future effect in any logical area fittingly.

This is a significant motivation behind why nanotechology is for the most part considered to be a troublesome innovation. As indicated by Brower and Christensen 1995,a innovation is viewed as troublesome when its use creates items with various execution credits that might not have been esteemed by existing clients. In the event of nanotechnology-this implies that it can impact upgraded or new nanotechnology-empowered items, administrations or cycles for existing or new business sectors. For a couple of years at this point, nanotechnology has been perceived as a promising new development trend-setter. This prompts a shift from the investigation of nanotechnology information towards a period of double-dealing. Nanotechnology is a problematic innovation peculiarity. Nanoscale semiconductors might prompt Computers that are quicker, more remarkable, and more energy proficient than those pre-owned today. Nanotechnology likewise holds the possibility to dramatically build data stockpiling limit soon the PC's whole memory will actually want to be put away in a solitary little chips. In the energy field, nanotechnology will empower high proficiency, minimal expense batteries and sun oriented cells.

There has been growing trend in development and innovation capacities in nanomanufacturing.

Electricity Storage: further developed productivity of regular battery-powered batteries which could be utilized in transport applications to decrease outflows or as back up for elective energy to permit exceptionally undeniable degrees of environmentally friendly power. Nanotechnologies are probably going to be utilized in creating supercapacitors, which give elective strategies for power stockpiling.

Thermovoltaics: new nanomaterials which transform squander heat into power. This could bring about critical energy investment funds in any application where ignition is the essential technique for energy generation(eg half breed vehicles).

Energy units: either as a component of a maintainable hydrogen economy or as productive hydrocarbon based power device, there is potential to decrease vehicular discharges or, as CHP (Combined hotness and power) plant, diminish warming and power age emanations.

Lighting: LEDs offer an energy productive option in contrast to regular glowing light sources. Nanotechnology is being utilized to foster these new light sources.

Motor/eco-friendliness: the utilization of nanoparticulate fuel added substances could diminish fuel utilization in diesel motors and further develop neighborhood air quality. Miniature and nanomaterials are likewise being utilized to further develop the hotness opposition of plane turbine blocks permitting the motor to have at higher fevers, which further develops the general motor productivity.

Weight decrease: novel high strength composite materials could lessen the heaviness of materials. Future objectives incorporate the decrease of vehicles weight using nanotubes in metal composites and plastics; further developed tires consolidating nanoparticles in elastic recipes and improved ignition processes in motors(nanotech catylic converters).

A portion of the improvements in the area of Nanotechnology which is en route to creation and dissemination.

Bimolecular

MEMS and Nanotechnology have empowered name free and versatile location of organically huge particles, for example, DNA, RNA, proteins and little atoms whose recognition in little amounts is of foremost significance for early sickness diagnostics. Momentum research regions include:

1) improvement of nanomechanical and optical biosensors and their application to discovery of an assortment of proteins including disease markers 2) novel receptor particles and their incorporation into biosensing, 3) biosensing utilizing nanoparticles, 4) quick identification of microorganisms and 5) affectability upgrade of biosensors. The work is right now upheld by NSF and NASA.

Miniature and Nano-Fluidics

Research in the miniature fluidics lab is amassed in two essential regions: test liquid elements in miniature/nano spaces and miniature manufacturing novel miniature fluidic gadgets. Progressing projects incorporate principal science (reaction of live cells to stream stresses, underneath right), key liquid mechanics (describing tiny supersonic streams, beneath left; nanoparticles stream elements), and portraying biomedical miniature gadgets. At present the Micro fluidics research center is upheld by the NSF (Ocean Biology and Nanoscale Science and Engineering), DOD (Crane-NSWC), SOI.

Computational Nanotechnology

Mathematical reenactment assumes a basic part in investigating novel nanoscale structures, materials, gadgets and frameworks. Research in this space is centered around the improvement of actual models and computational techniques to address various regions including arising miniature and nanoelectronics, stage change memory advancements, super quick laser producing, just as the essentials of nanoscale warm and liquid vehicle. Computational strategies incorporate novel limited volume procedures for the phonon Boltzmann transport condition, sub-atomic elements methods, just as multiscale techniques spreading over miniature, meso and full scale scales. Research in this space is upheld by NSF, the province of Indiana and the hardware business.

Nanoscale Manufacturing

Transforming the guarantee of nanoscience into new advances is probably the greatest test that face the exploration local area today. The bottleneck is the absence of advancements for assembling nanostructures and nanomaterials in enormous amount and for minimal price. Research in nano-producing is centered around creating optical based, minimal expense, enormously equal assembling strategies. In particular, a kind of nanostructure, called nanoscale optical radio wire is created to think energy of light into a nanoscale space, and is being utilized for nanomanufacturing reason. This program includes explores in a few disciplines, including fabricating science and designing, control, radiation, optics, and mechanics. It is right now upheld by NSF, ONR, and NASA.

Nanoscale Theramal-Electrical Transport

The interchange among warm and electrical energy at little scopes can firmly impact the useful conduct of many kinds of gadgets, for example, direct energy change components, heat sinks, and field-impact semiconductors. Research at the Nanoscale Thermo-Fluids Lab looks to resolve these issues by concentrating on novel nanomaterials, especially carbon nanotubes, both according to the point of view of material combination and portrayal and according to the viewpoint of practical designing execution. The research center's exercises incorporate point by point test and computational investigations amalgamation by plasma-improved synthetic fume testimony with applications to single-divider carbon nanotubes semiconductors, and multi-divider carbon

nanotubes exhibits used to upgrade warm/electrical connection point conductance, bubbling hotness move, and biosensor execution. Further, the lab has created special capacities to quantify and show warm electrical energy transport and change from nanoscale electron producers. Specialists in the lab regularly team up with electrical architects, material researchers, physicists, scientists, and scholars, and the work is upheld by NSF, NASA, the Air Force Research Laboratory, the Semiconductor Research Corporation, and an assortment of modern interests.

Warm Micro/Nanosystems

Warm vehicle is turning out to be progressively basic in the plan and execution of miniature and nano-frameworks. Research in this space incorporates the improvement of a scope of micropumping approaches and high-goal estimation strategies. Agent projects incorporate the advancement of a micromechanical electro hydrodynamics (MEHD) based fluid siphon with various driving components to convey high stream rates, and an ionic breeze driven hotness move improvement conspire. Different spaces of exploration incorporate microscale activation of fluids utilizing electrowetting and dielectrophoresis, slight film dissipation, single and two-stage microchannel transport and advancement of carbon nanotube-based hotness spreaders. Research results from these endeavors have direct applications in giving answers for the warm administration of microelectronics, and are upheld by NSF and the State of Indiana, other than a wide scope of modern backers.

Nano Thermo-Physical Engineering

The conduct of any actual framework can be connected with nuclear scale depiction. With a nuclear level information on the energy transporter (photon, electron, phonon, and liquid molecule) attributes and practices, one can climb to plan nano-and miniature designs with the ideal size impacts, or to orchestrate new materials with the ideal capacities. Research at the Nano Thermo Physical Engineering Lab tries to construct and extend the comprehension of the basics of nuclear level transporter transport and communications, and to apply this information to significant energy and data advances. Current undertakings incorporate the designing of electron-phonon coupling in quantum dab sunlight based cells, upgraded laser cooling of semiconductors and particle doped solids, controlled warm emanation utilizing adjusted miniature and nano-structures, thermo-optical administration of nano lasers, and so on 5.8 Advanced Micro/Nano mechanical Materials and Process Technologies To date, materials determination capacity in miniature/nano frameworks applications has been moderately restricted, due principally to the power of miniature manufacture cycles and foundation committed to silicon. While silicon has shown to be a brilliant material for some applications, nobody material can address the issues, all things considered.

Conclusions

Since nanotechnology covers a breadth of disciplines and also is a cost intensive technology in terms of material and infrastructure needed to support research, large initial investments will be necessitated to build capacity in their arenas. Since India desires to be on par with developed nations in nanotechnology to the extent possible the large investments in the global arena has resulted in a spillover effect in India. Simultaneously, the upsurge in the Indian Scientific Community's interest in conducting nano R&D as well as their vocal emphasis on the need to augment budgets culminated into policy makers rethinking the earlier funding frameworks. Research in this area, therefore, seeks to develop the materials and process technologies required for realization of applications that are either impractical or impossible using conventional silicon-based micromachining, e.g. biomedical and harsh environment applications. Areas of specific interest with this context that are currently under development include anisotropic titanium micromachining, micromechanical composites, and novel applications thereof. Focusing more on Nanomanufacturing, it is both the creation of nanoscaled materials, which can be powders or liquids, and the assembling of parts "lowest part up" from nanoscaled materials or "top down" in most modest steps for high exactness, utilized within a few advances, for example, laser removal, drawing and others. Nanomanufacturing varies from atomic assembling, which is the production of complex, nanoscale structures by method for nonbiological mechanosynthesis.

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