Nano Science and nano technology in Architecture

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Abstract— Scientists and architects have taken a great concern in the future. Aspirations have been longing to new practical optimum solutions. New Discoveries and new Technologies are evolving with no limits. Scientists look far in spaces .Though, they have focused closer and closer through atoms. Researchers have reached close enough to one billionth of a meter in Nanoscience, a new science that is growing with progress to be applied into many fields and applications like Pharmacy, electronics, medicine, and nevertheless to materials.

The task for architects today, is to seize hold of new technologies, judiciously apply them to buildings, delight in the symbolic potential, and endow them with poetic expression. - John M Johansen, FAIA, during a lecture at the Mummers (Stage Center) Theater in Oklahoma City.

Nanomaterial has played a significant role into many fields and it has found its way into architecture to serve sustainable and renewable approach. Architects will not build with the same conventional glass, concrete, bricks, instead new nanotech materials that will serve future needs. Nevertheless, sustainable and ecological ones will come to field.

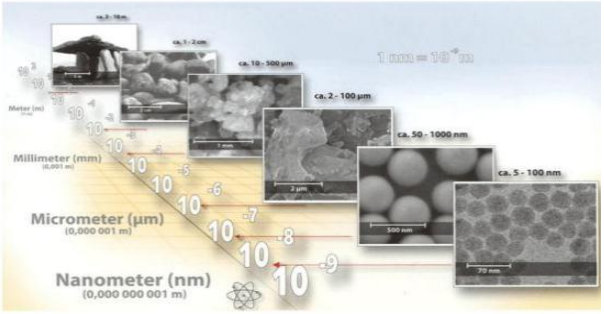
Index Terms— Nano Science – Nano materials – Nano technology – Sustainable Architecture – Surface Design – Clean Materials – Nano Applications – Nano Coating – Nano City - BioSensors.

1 Nanoscience

First hearing the word Nanoscience, you will understand it is the science of "Nano", but what is "nano"?. Nano refers to the metric prefix 10-9, i.e one billionth on something. It is after all a measurement very small one. Nanoscience is the study of structures and materials on the scale of nanometer by Texas Materials Institute (2014).

1.1 Definitions

Nordlund K. 2005 says that Nanoscience deals with the scientific study of objects with sizes in the 1 – 100 nm range in at least one dimension., and that Nanotechnology deals with using objects in the same size range to develop products with possible
practical application. It is usually based on nanoscience insights.
exactly! The quality and accuracy of the content of the electronic material submitted is crucial since the content is not



(1) NanoScale to a meter

They have begun introducing such science to students at early stages in schools through the GCSE program. They defines Nanoscience as the science of very small particles. They proceeded that Nanoscience looks at the properties of nanoparticles, these are particles with in the range of 0 ·1nm to 100nm.

The name 'nano' means 10-9.
A nanometre is one millionth of a millimetre. It is written nm.
1nm = 0 ·000000001 metres.

1.2 History

At Texas Materials Institute, some assumed the existence of the nanoscale in nature even before scientists has begun to study them in laboratories.

Johansen J. 2014 mentioned that the central thesis that nanotechnology is "capable of producing almost any chemically stable structure that can be specified" was first advanced by the physicist Richard Feynman in 1945. Prompted by Feynman, physicist-designer

William Katavolos expanded the study of MNT to the growth of architecture, foreseeing the production of a large floating city. Katavolos remarks, "We are rapidly gaining the necessary knowledge of the molecular structure of these chemicals with the necessary techniques that will lead to the productions of materials that will have a specific program of behavior built into them."

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While Mohamed O. has mentioned that the first concepts of nano was by the American physicist Richard Feynman at the American Physical Society meeting at Caltech on December 29, 1959.

1.3 Devices

In our daily life to magnify something, you will remember the magnifying glass, but it will only magnify ten times. To focus up to hundred times , you will use microscopes. Though, in the nanoscale , high-powered complicated microscopes that might take an entire room will be used.
According to the Nanoscience instruments website, the devices used in nanoscience are categorized to measure and scan many entities. These devices are:

1. Scanning Electron Microscopy
2. Atomic Force Microscopy
3. Scanning Tunneling Microscopy
4. Optical Metrology
5. Carbon Nanotube Synthesis
6. Micromechanical Testing and Manipulation

1.4 Laboratories

Many universities have set special laboratories for nanoresearch. Cambridge nanoscience center in Cambridge Universities has a 554 m2 Laboratory area that is divided into 15 separate modules. Even laboratories has specialized tasks some for Microscopy , CHaracterisation and wet lab.
Some of the Precautions and setting for lab is to have a vibration Isolated floors for Vibration Sensitive Microscopes and Optical/laser Systems.

1.5 Conferences

Bibliotheca Alexandrina has held many conferences about nanoscience and nanotechnology since 2007. Dr. Mona Bakr has been responsible of one main conference about nanoscience and nanotechnology one on 17th July 2011 in the name of 'nanoscience and Nanotechnology: discovering the magic in very tiny particles' . Dr. Mostafa el Sayed as well has presented a lecture on 29th March 2009 about the role of nanoscience and nanotechnology in medicine. The earlier conference has been held from 2nd till 4th September 2007 , it was a workshop about nanotechnology at the center for special studies and programs (CSSP) and about its applications

2 Nano Technology

2.1 Definitions

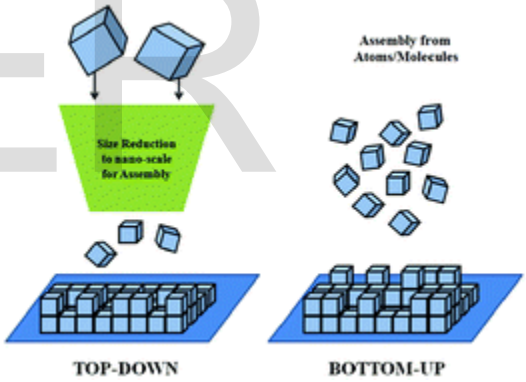
In the GCSE system they introduced Nanotechnology to be looking at the new uses of these small particles. Most of the essays about nanotechnology were about the use and utilizing nanoscience and its devices and tools to solve problems in many fields and disciplines.

The term nanotechnology was defined by Tokyo science University professor Norio Taniguchi in a 1974 paper as " Nanotechnology mainly consists of the processing of separation, consolidation, and deformation of materials by one atom or by one molecule"

Mohamed O. has defined it as the study of the control of matter on an atomic and molecular scale. Generally nanotechnology deals with the structure of the size 100 nanometers or smalled in at least one dimension.

Fahmy M. has assumed the two main approaches of Nanotechnology:

1. Bottom Up- materials and devices are built from molecular components which assemble themselves by principles of molecular recognition
2. TopDown – nano-objects are contructed from larger entities withour atomic-level control



(2) Bottom-up and Top-doan approaches

2.2 Applications

Since Nanotechnology is about the use of Nanoscience and the science of small particles and its manipulation, nanotechnology has found its way through many fields to solve critical issues . some of its application is through education, filtration, forensics and more effectively in pharmaceuticals and medicine.
Many disciplines have encountered the nanotechnology. In the nanotechnology journal , issues like diagnosis and treatment of infectious diseases

Pharmaceuticals and Medicine

Bibliotheca Alexandrina has been interested in nanoscience and nanotechnology. Conferences, lectures and workshops have been taken place under the supervision of Dr. Mostafa Elsayed about curing cancer and critical diseases using gold in medicine.

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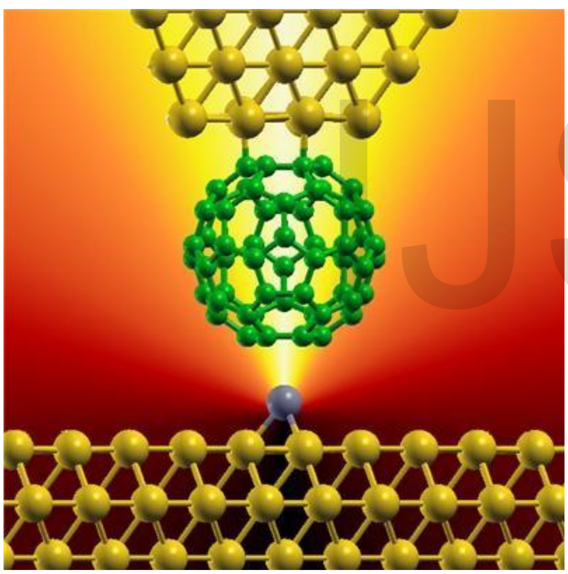
Many disciplines have encountered the nanotechnology. In the nanotechnology journal , issues like diagnosis and treatment of infectious diseases

3 Nano Materials

One of the significant applications of nanoscience and nanotechnology is through nanomaterials. Since nanoscience is concerned about the molecular structure of atoms.

At Texas Materials Institute, Scientists use beams of electrons or ions to etch features as small as 25 nanometers into metal, silicon, and carbon-based materials. They even used nanostructures in liquids. Nanostructures can be created by reacting chemicals in liquids and gases to generate nanofibers, nanocrystals and quantum dots, some as small as one nanometer wide. Scientists are even learning how to build three-dimensional structures at the nanoscale. Called nano-electro-mechanical systems, or NEMS, these devices might one day be used like microscopic robots to carry out tasks too small for humans to do themselves. For example, NEMS could carry out surgery on a single cell or act as mechanical actuators to move around individual molecules.

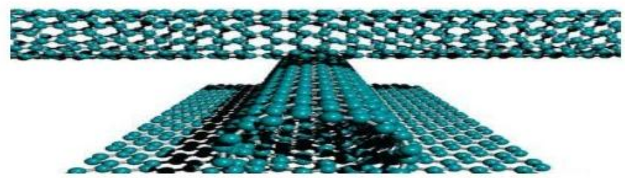


(3) Wiring up Carbon-based electronics

While at the Nanoscience Centre, Cambridge University nanofabrication and characterization facility, in the organic Processign facility, they work in nanomaterial through the carbon nanotubes (CNT's), nanoflowers, graphene, ZnO, SiC, TiO2 and VO nanowires, quantum dots, sol gels, colloids and precursors.

3.1 Carbon Nanotubes

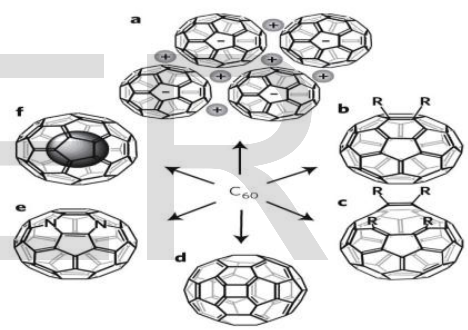
Nanomaterials has found a great discovery in 1991 through carbon nanotubes. According to Zain M. and Niroumand H.(2013) , these molecules exhibit exceptional mechanical, electronic and magnetic properties and have been noted to be 100 times stronger than steel but their weight to be one-sixth of a nanotube fiber. Because nanotubes have the ability to conduct electricity and heat much better than copper, they have been extensively used in polymers to enhance their conductivity and have also been used in the antistatic packaging industry.



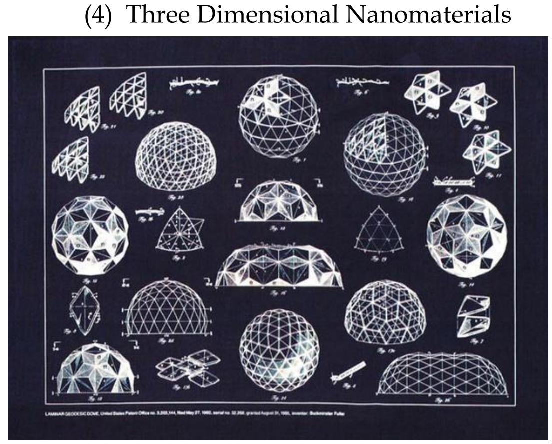
(4) Carbon Nanotubes

3.2 Three Dimensional Nano Materials (C60/ Fullerenes)

No one can ever forget Buckminster Fuller , the great architect who pioneered the geodesic dome that has been a great inspiration to architects and scientists who came after. Rick Smalley, Sir Harry Kroto and Robert Curl have won a nobel prize in year 1996 for their study on the synthesis of a new form of carbon , C60 that is called "Buckminsterfullerene" in the honor of the great architect.



(4) Three Dimensional Nanomaterials



(5) Buckminister Fuller Geodesic Dome

Zain M. and Niroumand H.(2013) stated that These C60 molecules are also referred to as buckyballs. In the architecture industry, geodesic domes are famous for their lightness and strength. However, the same applies to buckyballs too. It is seen that when buckyballs are fired at a stainless steel plate at 15 000 mph, they just bounce off the stainless steel plate. And

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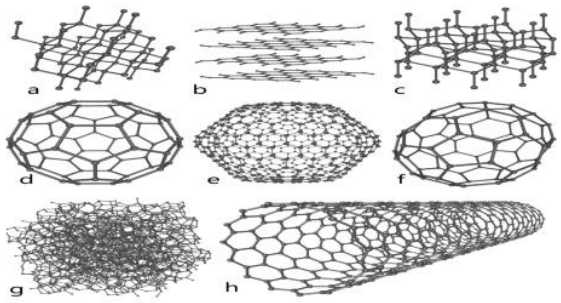
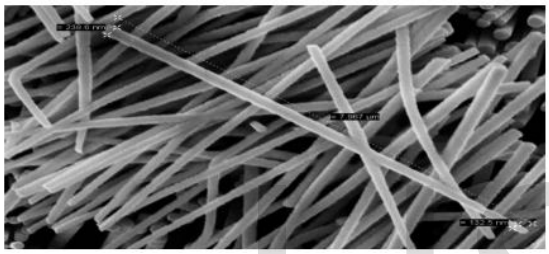
when buckyballs are compressed to 70 per cent of their original size, they become two times as hard as diamond. A fuzzyball, where all carbon atoms are combined with hydrogen, is found to be more slippery than Teflon and is used to coat bowling balls.



(4)Types of Nanomaterials based on dimensions

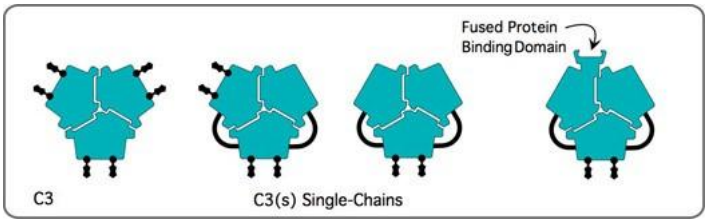


(4) Nano Wires

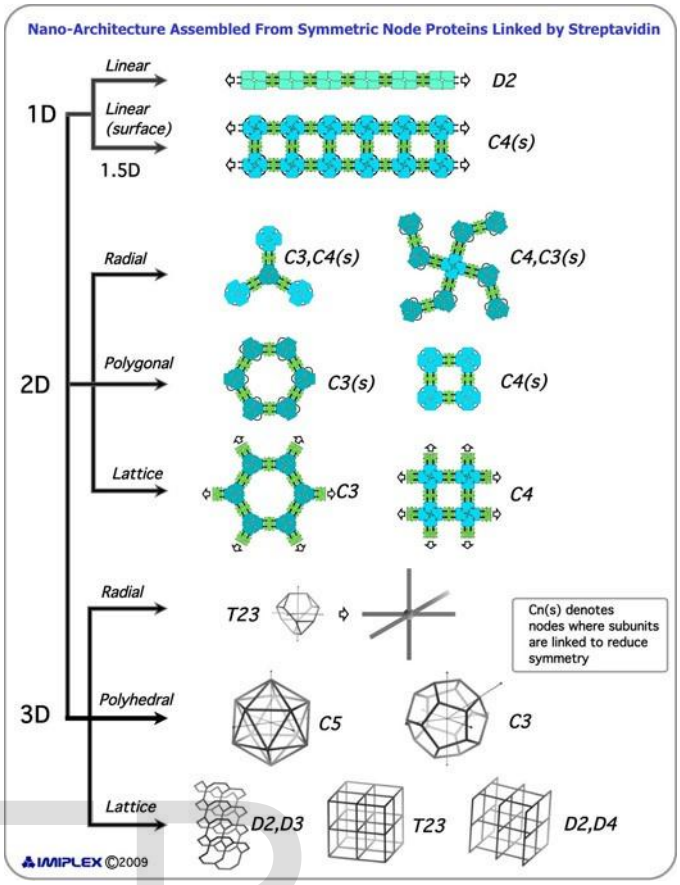
3.3 Biosensors

The Imiplex platform is based on the development of a modular set of nanostructure building blocks that enable construction of highly customizable architectures. The nanostructures are assembled from "struts", that are basically linear structural elements, and "nodes", that have plane or point group symmetry. Components are designed to incorporate features so that nanostructures assembled from struts and nodes can be additionally functionalized through attachment of other proteins (e.g. antibodies, protein and peptide binding domains, growth factors) to create a great variety of precision nanostructures with biomedical research or practical applications such as biomaterials, biosensors or diagnostic devices.

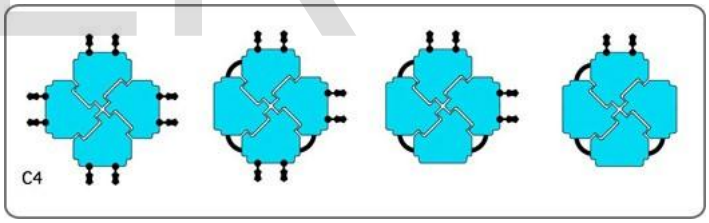
This scalable mutilnode concept was mainly used in the manufacturing and the components of biosensors that can serve many fields adding new and different properties and options to users.



(6) Nodes with C3 , and C4 Symmetry



(6) Modular set of Nanostructure building



3.4 Nanomaterials in Architecture

One of the significant Emergence of Nanomaterials is in Architecture through biomimetic Glass that overcomes brittleness by bending. Even in Paintings , you can imagine a nanohouse with nano paints that has no risk on health.

Sustainability is all about renewable energy and decreasing wastes. Solar energy is a very important and reliable clean energy source that has forced scientists to improve its technology. Thus , nano approach played a great role through a nanostructures paper that improves solar cell performance.

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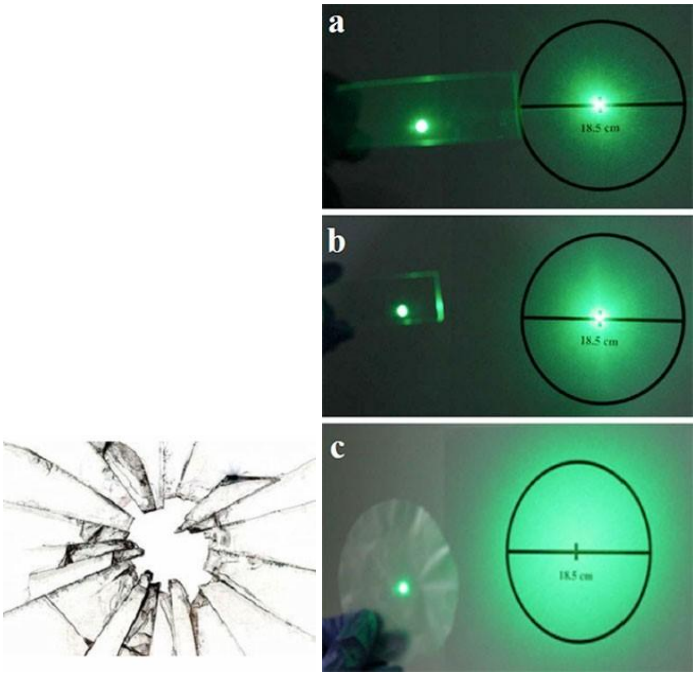

(7) Biomemitic glass-nanostructures paper

(5) Self-cleaning restroom

Keeping clean materials have taken a share from scientists thinking as well. Sullivan C., 2012 has mentioned that the Japanese potty maker "Toto" has quietly unveiled a product called Hydrotect which like the nano-infused paints and glass coating we've see, promises to keep itself clean. In Asia recently a similar product, an ultrathin, large-sale ceramic board named Hydrocera has been shown. It has a hydrophyllic, photocatalyti technology that is stain and odor – resistant . otherwise , in USA you can not mention the word 'antibacterial' or 'bacteriostatic'.

(5) Fast-drying concrete

Concrete is a basic and a common used mixture in buildings and constructions. Thus, it takes long time to dry, architects is still relying on it in most of their construction. Scientists have served us in finding a fast-drying concrete. The mix is called Aridus, and it is produced by Houston-based U.S. concrete. It is made with regular old Portland cement but adds a special sauce through chemistry. The result acts a s desiccant, basically: water is used and bound internally so the concrete reaches an internal 75 % RH with water loss of 3 pounds per 1,000 square feet per 24 hours in 45 days or less.

NanoTechnology added a new invention into Facades through a highly insulating Vacuum ones. Sullivan C., 2012 stated that new working prototypes of VIPs made from pyrogenic silica and high-tech thin films were created at Germany's Fraunhofer institute . The VIP's inner components insulate as well or better than a traditional insulated façade ten times as thick.

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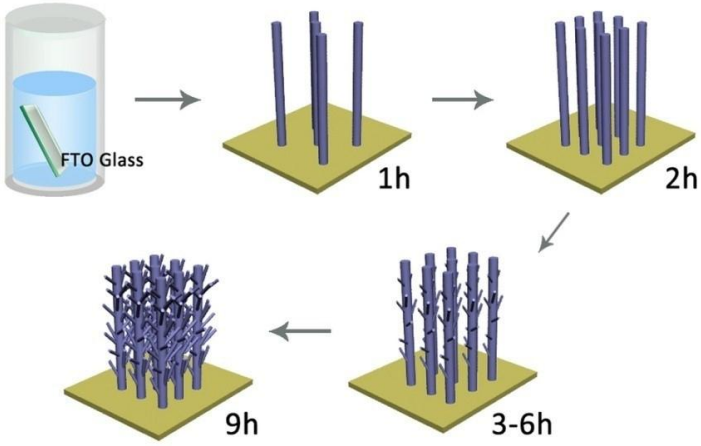


(8) Schematic formation process of hierarchically anatase TiO2 nano-architecture arrays on FTO glass.

Solar cells glass has taken a wide study to nanotechnology scientists to improve its performance and functionality . Wu W., Lei B., Rao H., Xu Y., Wang Y., Su C., and Kuang D., 2013 have worked through the growth model shows the formation of hierarchically anatase TiO2 nano-architecture arrays wars intelligently assembly and the short branches became more numerous and longer on the surface of TiO2 nanowire trunk with the prolonging reaction time.

Sylvia Leydecker

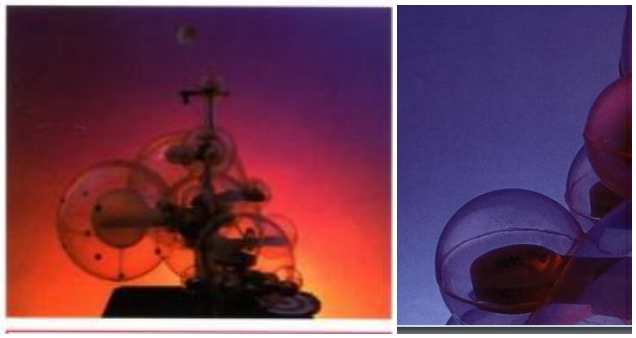
Sylvia Leydecker has studied faar itno nanoscience and its implication on architecture through materials. She assumed that nanotechnology brings us a step closer towards customized materials with specific individual properties and represents a shift away from the catalogue of standard materials.

(1) Nanocoatings – Raw Material

Not only Nanocoatings that will result an emergence in architecture. Leydecker S. assumed that the chemical industry which sits at the beginning of the chain as a supplier of raw materials for further processing will be affected by those nanoparticles to produce new different substances. The most common nano raw material include polymer emulsions, aerogels, and zeolites, carbon black, dendrimers, nanosilica and metallic nanoparticles, titanium dioxide, ceroxide and aluminium oxide.

4 Nano Architecture

Many architects have persisted in coping with technological and scientific progress and evolution . one of them is Johansen J. who has been always at the cutting edge to new technologies from nanotechnology , bioengineering, magnetic levitation. From floating conference center to an apartment house that literally sprouts from the earth.



(9) New Species of Architecture

Architect John Johansen has gone wild with his imagination to apply nanotechnology not to just houses but to a multi story building with more sophisticated structure , grown in stages following coding strategies. He assumes pursuing the same molecular-engineered house growth process , but instead it is applied to a building . The building will start from vats at the building site, root, stalk, branch, platform, lattice, membrane, and openings develop, light control, self-cleaning, repairs and demolition systems also emerge.

(10) Growth of a Multistory Apartment Building by Architect John Johansen

Inspired by nature, Johansen J. assumed By planting seeds in what many predict will be the future of architecture, Johansen firmly believed that his nanoarchitectural ideas and designs will some day provide the foundation for buildings that will be "grown" from the subatomic level.

"Nanoarchitecture will be used to create the buildings of the future - structures will function in symbiotic relationship to

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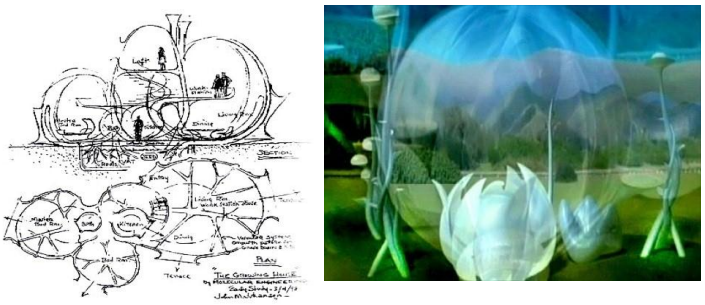
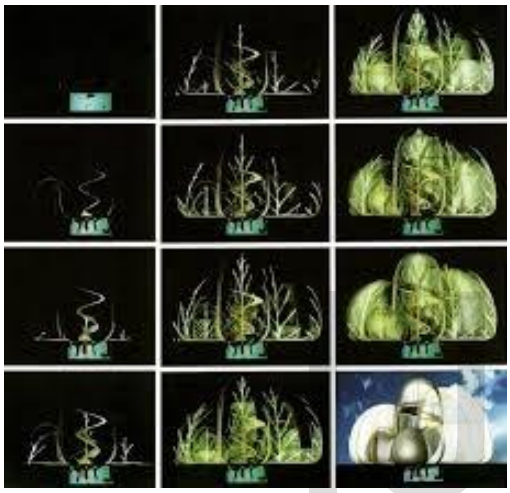
the environment, adapting to the changing needs of their inhabitants." - John M Johansen

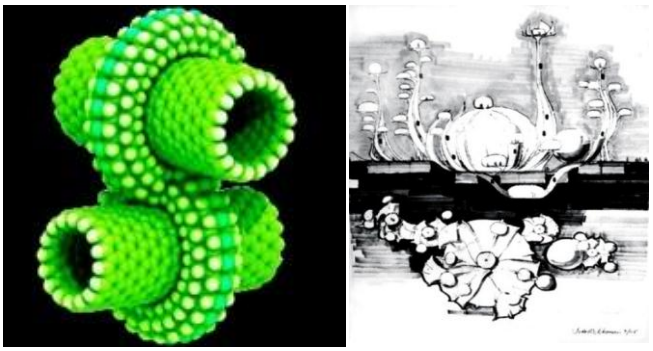


(10) Molecular engineered House



(10) A Growing Nanohouse
Johansen J. has gone far in imagining nanoarhitecture and applying nanotechnology in architecture that he has built an exihibition in Netherlands at stroom museum. Regarding the combination of organic properties with the inorganic properties of technology in the creation of nanoarchitecture Johansen remarked, "... as technology advances in architecture, the closer it comes to nature."

(10) Nanoarchitecture Exhibition



(10) Molecular DNA Growth – Molecular Building Process
Johansen J. Imagined The molecular building process is not biological, but mechanical;
living cells are replicated by dividing, assemblers replicate mechanically, by building others. As Drexler has written: "The great difference is that nanotech use not living ribosomes but robotic assemblers, not veins but conveyor belts, not muscles but motors, nor genes but computers, not cells dividing but small factories producing products and additional factories."

(11) Nano Towers By Allard Architecture
In ArchiCentral, they have described those Nanotowers as the new headquarters of the DuBiotech Research Park in Dubai. This mixed use development offers 160 000m2 officespace, laboratories, hotel, residential and associated support facilities in a 262m high tower. The canopy at ground level provides sunshading while creating a dramatic entrance to the towers: a conceptual ground plane from which the towers grow.

(11) Nano Towers By Allard Architecture
ArchiCentral continued that Architecturally interesting is the repetitive grid of the exoskeletal structure, which has non-curved beams of equal length. The entire facade of the tower is

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faceted, inspired by a nano scale carbon tube, the structure creates junctions where the geometry shifts from vertical to horizontal. This creates multiple opportunities for dividing the interior space along mullion lines.'

4.1 Nano Architecture and Sustainability

EMPA stated that the integration of engineered nanoparticles (ENPs) in façade coatings may lead to improved or new functionalities during their life cycle and may bring several sustainable advantages; they may replace hazardous substances, prolong the life time of façade coatings and they can be advantageously used for air purification, thermal insulation, self-cleaning, and other. Nevertheless, the use of nanomaterials in this economic area can grow dynamically only if the safety of humans and the environment is satisfactorily resolved.

Sylvia Leydecker has progressed in nanomaterials. She mentioned thatUltra-thin and invisible nanocaotings whose applications are particular interest to designers generally have a thickness of 5-10 mm when sprayed automatically a phenomenon that is called " self-organisation' . combining this self-organization with the chemical technique bottom up approach it will develop from the smallest size to the larger sizes. This coating might cause as a direct result in:

- Reduction in the consumption of raw materials and energy and reduced co2 emissions
- Conversation of resources
- Greater economy
- comfort

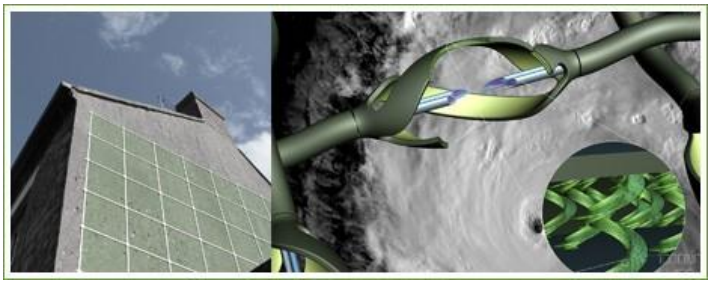
(1) Nano Coatings

Mohamed O. has mentioned that Green Nanotechnology will contribute by two main aspects or directions:
Nanomaterials and products that will consider environmental aspects utilizing gree chemistry and green engineering. It will not harm the environment or human health without toxic ingredients , at law temperatures using less energy and renewable inputs. Using the lifesycle concepts in design stages.

Developing products that benefit the environment either directly or indirectly. It can be a cleaning factor to site wastes , desalinate water, treat pollutants, or sense and monitor environmental pollutants. New transports that will save fue and reduce material consumption.

4.2 Agutin Otegui

Ecological and sustainable architecture has captured a great interest last years. Architects, engineering and even scientists have been looking for several ways and new technologies to serve the ecosystem. Though, carbon emissions might cause a global disasters (Global warming), factories are still built and continues to function. Nanotechnology provided new facades that will suck carbon emissions in air.



(12) A Nano Vent-Skin Syncs Solar , Wind and Co2 Suckers

Agustin Otegui is working on a resourceful way to get the most green out of a building's façadeas Heimbuch stated. He also assumed that the skin is a zero-emissions material that absorbs sunlight with its photovoltaic layer, transferring the energy through nano-wires to be stored at the end of each panel. The skin is also covered in tiny turbines that have a very different take on wind power generation. First, the inner skin of the turbines soaks up CO2 as wind passes through. Second, they utilize "polarized organisms" that create chemical reactions, generating power when the turbine makes contact with the structure. Wonder bugs, me thinks. Yet they are not genetically altered – rather, Otegui says, they are trained to work together towards specific tasks. Like a colony of circus ants, I suppose.

(13) Wind Turbine Tower

Chino M. added that the concept takes advantage of a structure's maximum available surface space, and its modular composition allows it to retrofit our old buildings instead of pouring resources into new ones. Plus, the stunning superstructure incorporates micro-organisms to soak up C02.

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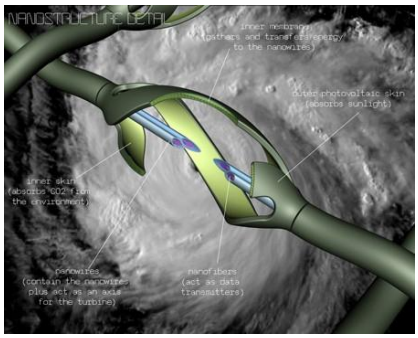
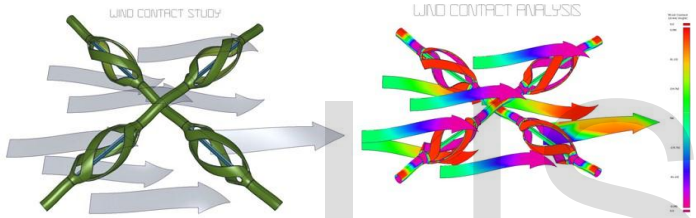
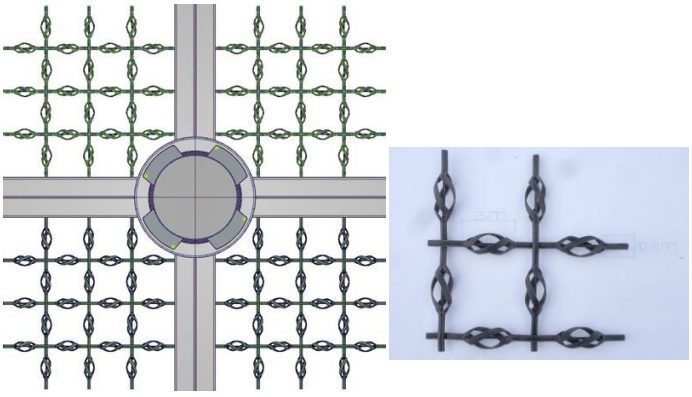


(14) Nanostructure Detail

In Dezeen magazine , Nano Vent-skin is a conceptual project by young designer Agustin Otegu, featuring miniscule bio-turbines that could clad buildings to generate energy and absorb carbon dioxide from the atmosphere. The project suggests using several kinds of micro organisms to create a material which performs different functions where needed, absorbing and transforming natural energy from the surroundings.



(14) Wind contact Study – Wind Contact Analysis
Dezeen Maganzine mentioned that with this approach Nano Vent-skin tries to make existing objects greener with a skin made out of micro wind turbines.NVS is a set of micro turbines (25mmx10,8mm), which generate energy from wind and sunlight



(14) NVS
How Does it work? In Dezeen magazine , they have explained that Each panel has four round supply units (one on each corner). These units are in charge of:
Monitoring that all the turbines are working.

Delivering material to regenerate broken or malfunctioning turbines.

Receiving and storing the energy produced by the turbines.

5 NANOCITY

India has the lead to follow nanotechnologies and architecture seeking a sustainable city. Nanoscience has not stopped at architecture, Architects and planners tried to follow nanotechnologies in urban planning. Two cities in India have been considering such approach to achieve new goals and apply new methods towards a sustainable city.

(15) Nano city (BGAP)
Nanocity in india is a real project that has captured the press and media of whole India and even the world. NRI Entrepreneur stated that NRI Sabeer Bhatia, co-founder of Hotmail, Parsvnath Developers and the Haryana Government has announced to develop an 11,138 acres knowledge city with the total project cost of Rs 50,000 crore. The name of the city will be "Parsvnath Nano City."

(16) Nano City , near Mohali , Haryana , Area = 11138 Acres
NRI mentioned that the Idea came in 2006 when he was watching a cricket match in India with a government official from Punjab, pitching a plan to bring premier U.S. educational departments in science and technology to Indian universities. He returned to the United States, having agreed to write a

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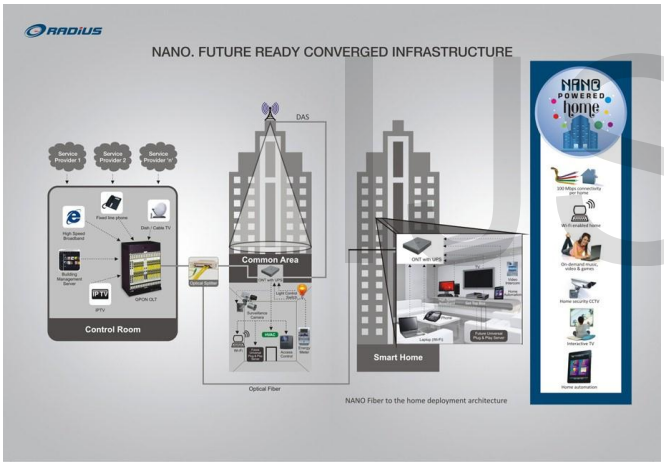
proposal. But he considered the conversation the kind of casual banter one has at a sporting event, something not to be taken too seriously. Later on, Sabeer's cousin Naval Bhatia, an attorney, mentioned the conversation to a friend, an official in nearby Haryana.

(16) Nano City , Near Mohali , Haryana

The nanocity will depend on a complete different infrastructure. A nano infrastructure will create new properties and will utilize technology to offer sustainable demands. Preparing the future for a converged infrastructure.



(18) Nano Infrastructure

4 Conclusion

+ Nanoscience is a growing science that has found its way through many fields and applications.
+ The use of Nanoscience through nanotechnology is applied in Education, Filtration, Forensics, Pharmaceutical, nanomaterials that is affecting architecture in a remarkable way.
+ Nanotechnology has found its way though many applications, disciplines and fields .
+ one of the most significant use of nanotechnology is in nanomaterials.
+ Nanomaterials played a great role in the developing of many fields especially architecture through finding

1. Self-cleaning Paint
2. Fast Drying Concrete
3. Highly Insulating Vacuum Facades

+ Nanomaterials contributed in the evolution of the high-rise building through nanotowers that can be internally divided in unconventional way.
+ Nanotechnologies and nanomaterials have combined in approaching a new sustainable cities.
+ A modular approach can be applied to nanostructure buildings , following the concept of DNA and the growth of living organisms that can be true in buildings by nanotechnologies and nano industries.
+ Nano Vent-Skin is an outstanding blast in the technology of buildings that serves ecological demands as well by

1. Absrobing energy from wind and sunlight
2. Sucking Carbon emissions and decrease the carbon in the atmosphere.

+ Leydecker S. has studied nanomaterials and its implication in the chemical industry through raw materials that will be severely affected and influences by nanoscience. The most common nano raw material include polymer emulsions, aerogels, and zeolites, carbon black, dendrimers, nanosilica and metallic nanoparticles, titanium dioxide, ceroxide and aluminium oxide.
+ Sustainable Architecture will be greatly influenced by the nano coating that this coating might cause as a direct result in:

1. Reduction in the consumption of raw materials and energy and reduced co2 emissions
2. Conversation of resources
3. Greater economy
4. Comfort

+ Green Nanotechnology will play a great role into sustainable deisgn and preserving the ecosystem fundamentals directly or indirectly through

1. Nanomaterials and products that will consider environmental aspects utilizing green chemistry and green engineering.
2. Nanomaterials that will not harm the environment or human health without toxic ingredients
3. Nanomaterials that is at low temperatures using less energy and renewable inputs. Using the lifecycle concepts in design stages.
4. It can be a cleaning factor to site wastes , desalinate water, treat pollutants
5. It might be used to sense and monitor environmental pollutants.

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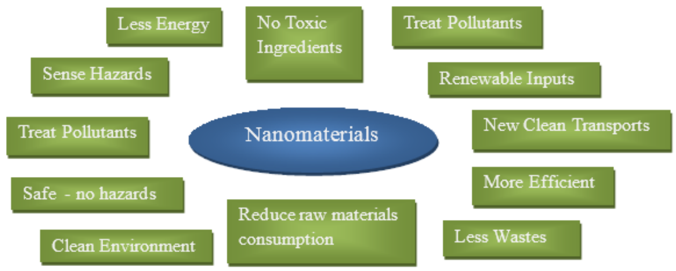
6. New transports that will save fuel and reduce material consumption.



Role of NanoMaterials in Sustainable and ecological design
Source: Researcher

+ Nanotechnology depend on two main approaches:
1. Bottom – up; to build the molecular components that is assembled chemically according to molecular principles
2. Top-Down; to build nano-objects from larger entities away from the atomic level.

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