Paper's No. BUE-FISC – 13

SMART MATERIALS – TOWARD A NEW ARCHITECTURE

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ABSTRACT:
The latter few years have been marked by a new generation of buildings: buildings with various degrees of high technology, which are extremely ecological in their behavior through the intelligent use of functionally adaptive materials, products and constructions that are able to react to changes in their direct or indirect surroundings and adjust themselves to suit.

This creates new tasks for the designers and planners of these buildings, who must know, the design process requires knowledge and integration of many parameters belongs these new "smart" or "intelligent" materials and technologies for solutions to long-standing problems in building design.

The goals of this research are to focus on materials that combine questions of sustainability with the performance of building materials and to suggest a methodology that shall help architects and designers in choosing a suitable smart material for building design.
The paper defines the terms Smart Materials and Smart Technologies in architecture, pointed out the architectural perspectives in order to assess how architecture can develop further by using the new technologies, describes examples on completed projects and/or experiments by architects that deepened the knowledge. The research expounds the effectiveness of using smart materials to become an agent "towards a new architecture".

Conference Topic:
Keywords:
Smart Material, Building Systems, Sustainable Architecture.

1. INTRODUCTION:

Smart planes – intelligent houses – shape memory textiles – micromachines – self-assembling structures – color-changing paint – nanosystems. The vocabulary of the material world has changed dramatically since 1992, when the first 'smart material' emerged commercially in, of all things, snow skis. Defined as 'highly engineered materials that respond intelligently to their environment', smart materials have become the 'go-to' answer for the 21st century's technological needs.

Apart from that new materials play a major role in architectural practice and research: The enhancement of traditional materials, such as reinforced concrete, can be achieved with the employment of high strength concrete or textile reinforcement. Further on smart materials are able to adapt their physical or chemical properties, in order to optimize the mechanical or thermal response of a structure or building. This in combination with innovative manufacturing processes will lead to new concepts in architectural engineering.

2. ARCHITECTURE MATERIALS:

After reviewing several existing and common approaches for material classification, we will provide as:

2.1 Engineering classifications:

State: Solid. Liquid, Gas
Origin: Natural, Synthetic
Processing: Cast, Hardened, Rolled
Environment: Corrosive .Underwater
Structure: Amorphous, Crystalline
Composition: Organic, Inorganic, Alloy
Property: Emissivity, Conductivity
Application: Adhesive, Paint, Fuel, (D. Addington & L. Schodek , 2005).

2.2 Classification based on building components:

Structure materials: as Metal, Concrete, Stone, Brickwork, Timber, Turf, .ect.

Surface materials: Metal surface materials, Non-metallic mineral surface materials (Roofing, Sheets for cladding, Plaster, Flooring), Stone surface materials, Fired clay, Surfaces of earth. Bitumen-based materials ,Plastic surface materials ,Living plant surfaces (Planted roofs, Wall cladding with plants, Indoor plants) ,Timber sheet materials (Roof covering, Timber cladding, Wooden floors, Natural rubber (latex) ,Wood-based boards) ,Grass materials (Roofing and wall cladding with grasses, Grass boarding, Soft floor covering of, and linoleum) ,Boarding from ,domestic waste ,Carpets and textiles .

Building accessories materials: Windows and doors (Glass, Timber, Plastic, aluminum…), Stairs, elevators (Bjørn, 2009)

Finishing materials: Paint, varnish, stain and wax with mineral binders (Lime paint ,Silicate paints ,or with organic binders (Synthetic paints and varnish ,Animal glue paint ,Vegetable oils ,Tar Natural resins ,Starch paint ,Cellulose products) ,Stains ,Wallpapers.

Services: using different materials for Lighting, Air conditioning, electrical services, gases supply, water supply and distribution, draining supply, trash compactor.

2.3 Innovative materials classifications:

Recyclable Materials: These materials are manufactured mainly from crushed and cleaned waste.

Biodegradable materials: That are decomposed and completely broken down by microorganisms living in the soil.

Biomaterials: Plastics and other materials made from renewable sources.

Nonvariable materials: These materials are largely unaffected by physical and chemical influences.
Functional Substances: A general term for monofunctional and multifunctional substances.
Smart Materials: These materials have change properties and are to reversibly change their shape or color in response to physical and –or chemical influences.
Hybrid Materials: These materials are manufactured by combining at least two different components.
Functionally Gradient Materials: Composite materials with gradually merging layers. This results in a continuous change in material properties.
Nanomaterials: Materials made from nanometer scale substances, (Axel Ritter, 2007).

2.4 Classification based on function/system:

This classification establishes a sequential relationship between materials, technologies and environments.
Traditional materials, High performance materials: Fixed responses to external stimuli (material properties remain constant under normal conditions)
Smart Materials: (Type1- Property-changing) Intrinsic response variation of material to specific internal or external stimuli (Thermochromic, Magnetorheological, Thermotropic, Shape memory), (Type 2– Energy exchanging) Responses can be computationally controlled or enhanced (Photovoltaic, Thermoelectric, Piezoelectric, Photoluminescent, and Electrostrictive).
Smart devices and systems: Embedded smart materials in devices or systems, with intrinsic response variations and related computational enhancements to multiple internal or external stimuli or controls.
Intelligent environments: combined intrinsic and cognitively guided response variations of whole environment comprised of smart devices and systems to use conditions and internal or external stimuli, (D. Addington & L. Schodek, 2005).

3. SMART MATERIALS/SYSTEM: CHARACTERISTICS, RESPONSES, AND APPLICATIONS:

Sensitive and reactive materials, products and constructions are required to help building react dynamically to various influences for reasons of stability and energy absorption, for example. Variable/ changing materials and products are capable of changing their properties themselves or their properties being changed by external influences such as the effect of light, temperature, force and/ or the application of an electrical field. These influences may lead to changes directly without conversion on the energy environments (luminous, thermal, and acoustic), or indirectly with conversion on systems (energy generation, mechanical equipment), (Axel Ritter, 2007). Smart materials can be defined within two main typologies: property- changing, energy-exchanging as we shown in the classification based on function/system. A smart material has an inherent “active” behavior that makes it to fit into several categories. For example: electrochromic glass is simultaneously a glazing material, a window, a curtain wall system, a lighting control system or an automated shading system. It has a lot to do with new technologies (D. Michelle Addington &Daniel L. Schodek, 2005), recent developments in material research now allow coming to real-world practical, commercial applications. Nowadays materials such as phase-change-materials, electro-chromic glasses and coatings, based on nano-technology, are available and the task is to span the gap between this material level to large scale architecture and building engineering applications. Apart from that another challenge is to leave the idea of "static systems" behind and develop systems, which possess dynamic properties to react to external changes in the environment, (Dr.-ing. P. Teuffel, 2009)

3.1 NanoMaterials (Nanotechnology):

"Nanotechnology refers to the creation, investigation and application of structures, molecular materials, internal interfaces or surfaces with at least one critical dimension or with manufacturing tolerances of (typically) less than 100 nanometres components results in new functionalities and properties for improving products or developing new products and applications." The material out of which nanoparticles are made is nothing out of the ordinary. The basic material of nanoparticles can be organic or inorganic, for example silver or ceramic. In the building sector, nanotechnology is an "enabling technology", a fundamental technology that helps to make other technological developments possible, (Sylvia Bedecked, 2008), The challenges for nanomaterials synthesis lie in the design and tailoring of complex hybrid nanoparticles and 'intelligent' or 'smart' nanomaterials (nanotubes, functionalized surfaces, multi-layers, novel thin films and interfaces) with multiple functions for urgent applications,

(Michael Berger, 2010), this innovative technology include layers of nanoparticals which can make glazing especially water-repllent or spectrum-selective, or paints and plastics extremely scrach- resistant. Glazing can incorporate suitably thin dichotic filter layers Nanoparticles can also be used in gypsum wallboard to improve room air quality. Examples of nanoparticles used are titanium dioxide (Tio2) and zeolite (Type1-property-changing, photoadhestive smart materials). In a similar context, membranes with nanometer-scale pores are currently being developed to be used as part of facades with the ability to clean polluted city air.

Fig.1 NanoMaterial (using titanium dioxide), For self cleaning, Air Purifying.
Indoor and out door, (Axel Ritter, 2007), (Sylvia Bedecked, 2008).

3.2 Smart Materials and Adaptive System:

Based on the availability of smart materials one important aspect in this field is the introduction of adaptive systems into architectural and engineering projects, which allows a new approach to design: apart from traditional concepts, such as "form follows function" or "form follows force" the amount of energy brought into the system can influence the optimum solution of the overall system: "form follows energy". Actually the idea of multiple states of a system is not new, (Dr.-ing. P. Teuffel, 2009).

3.2.1 Adaptive system definition:

The three main components of smart or adaptive systems are defined as the sensors, the actuators and a control unit. Sensors are one key component of any adaptive system. They must be able to measure different parameters at various points at various times. The parameters of interest differ from system to system; nevertheless following categories might be relevant: mechanical measurements, such as stresses or strains or environmental measurements, such as temperature, light emission or corrosion. Actuators are the elements, which cause changes in the controlled system, in order to achieve the desired specified condition. They serve to convert the electrical output signals of the monitoring unit into a reaction, such as translation or rotational movements. Apart from conventional technologies, such as electromechanical- or hydraulic devices, nowadays new evolutions using smart materials are thinkable. (Dr.-ing. P. Teuffel, 2009).

3.2.2 Smart material as adaptive system:

An advantage of the use of both property-changing and energy-exchanging smart materials within the context of sensor/actuator systems is that many of the actions described occur internally within the materials themselves. In some cases the sensor/actuation cycle is completely internalized. In other cases, additional elements may be required for certain kinds of responses, but the complexity of the system is invariably reduced.

For Type 1 property-changing materials, there are intrinsic and reversible property change responses. The constitutive model I, shown in Figure 2, can be used to describe basic input and output relations for Type 1 smart materials. When the full advantages of a complete control system are desired, including programmable logic capabilities or closed loop behaviors, it is clear that energy-exchanging smart materials that can generate electrical signals would be a seamless improvement.

While the behaviors of energy exchanging materials are not normally programmable in the accepted sense of the word, they can easily become part of a complex system and still serve to reduce its overall complexity. The constitutive model II, shown in Figure 2, can be used to describe basic input and output relations when these kinds of Type 2 energy-exchanging materials are used.

It is interesting to note that more and more research is directed towards making as many overall system behaviors as internalized as possible. Ultimately, smart materials offer the possibility of making the overall system seamless, (D. Addington & L. Schodek, 2005).

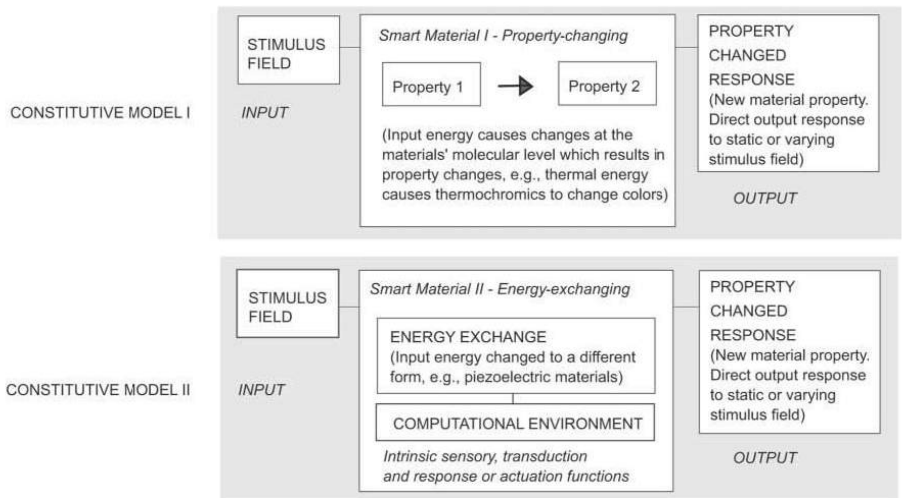


Fig.2 the input/output control models for smart materials type-1 and type-2
, (D. Addington & L. Schodek, 2005).

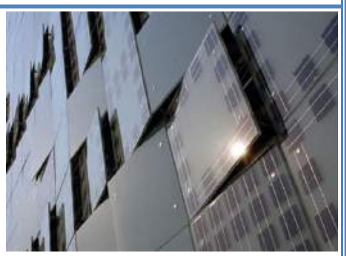
3.3

Smart Materials and Building System Needs:

The materials and technologies that are integrated into the building construction, whether it is in the foundation or the electric system, are much more immune to change than the products and ornaments that fill and decorate our buildings. In table 1 'maps' smart materials and their relevant property characteristics to current and/or defined architectural applications. With the exception of some of the glazing technologies, most of the current applications tend to be pragmatic and confined to the standard building systems: structural, mechanical and electrical.

As these systems are often embedded within the building's infrastructure, many of the smart materials tend to be 'hidden'. Building that is more important to determining its public presence than the exterior facade. In contrast, lighting systems perhaps have the most impact on the user's perception of the building, and while enormous developments have taken place in this area, they have not percolated as much into the architect's consciousness. Energy systems have steadily become more important as concerns regarding the global environment have mounted. Nevertheless, there remains much confusion as to the role that a building can or should play in the complex web of energy generation and use. One of the most interesting and least visible of smart material applications in a building involves the monitoring and control of structural systems. (D. Addington & L. Schodek, 2005)

Table.1 Mapping of typical building system design needs in relation to potentially applicable smart materials(D. Addington & L. Schodek, 2005)

BUILDING SYSTEM NEEDS	RELEVANT MATERIAL OR SYSTEM Characteristics	REPRESENTATIVE APPLICABLE SMART MATERIALSMATERIALS	
Control of solar radiation transmitting through the building envelope	Spectral absorptvity/transmission of envelope materials	Suspended particle panels ,Liquid crystal panels Photochromics , Electrochromics	 surfaces changing in color
	Relative position of envelope material	Louver or panel systems , exterior and exterior radiation (light) sensors-, photovoltaics, photoelectrics ,controls/actuators ,shape memory alloys, electro and magneto restrictive	
Control of conductive heat transfer through the building envelope	Thermal conductivity of envelope materials	Thermotropics, phasechange materials	
Control of interior heat generation	Heat capacity of interior material	Phase-change materials	 materials can transfer energy
	Relative location of heat source	Thermoelectrics	
	Lumen/watt energy conversion	Photoluminescents, Electroluminescents, light-emitting diodes	
Energy delivery	Conversion of ambient energy to electrical energy	Photovoltaics, micro- and meso energy systems (thermoelectric, fuel cells)	
Optimization of lighting systems	Daylight sensing Illuminance measurements Occupancy sensing	Photovoltaics,Photoelectrics, pyroelectrics	

	Relative size, location and color of source	Light-emitting diodes (LEDs),electroluminescent double photovoltaic glass (optimization of lighting system	
Optimization of HVAC systems	Temperature sensing Humidity sensing Occupancy sensing CO2 and chemical detection	Thermoelectrics, pyroelectrics, biosensors, chemical sensors, optical MEMS	 integration of electronics and bio chemical functionalities
	Relative location of source and/or sink	Thermoelectrics, phase-change materials, heat pipes	
Control of structural systems	Stress and deformation monitoring Crack monitoring Stress and deformation control Vibration monitoring and control Euler buckling control	magnetorheologicals, shape memory alloys Fiber-optics, piezoelectrics, electrorheologicals (ERs),	

4. CASE STUDIES: CONTEMPORARY EXAMPLES AND APPLICATION IN BUILDINGS AND ARCHITECTURE:

4.1 Geotube, dubai by faulders studio:

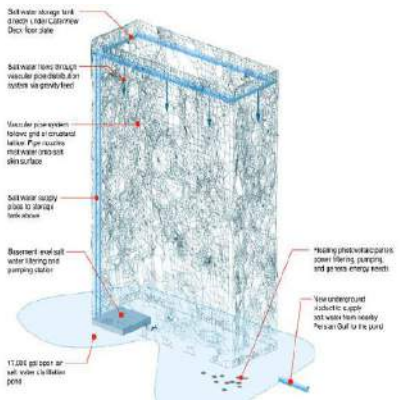
Proposal for a 170 meter sculptural tower by Californian architects
GEOtube is a proposal for a new 170 meter tall sculptural tower for the city of Dubai. With an open structure and an exposed membrane skin, the vertical planes of the GEOtube tower are continually misted with local salt water via an external vascular water system. The result is a continual uniform growth of salt crystal deposits upon its vast and highly visible surfaces. (http://www.faulders-studio.com)

Fig.3 Geotube, Dubai by Faulders Studioa specialized habitat for wildlife (http://www.designboom.com)

Materials: As the water evaporates and salt mineral deposits aggregate over time, the tower's appearance transforms from a transparent veil to a vibrant white vertical plane.

Becoming a new vertical natural habitat and harvesting surface, photovoltaic panels consider the application of smart material/system type2. **Sustainability factors**: The first one is the using of salt crystals which produce air saturated with healthy negative ions. In contrast, pollution produces large quantities of positive ions creating an unhealthy electrical imbalance in the air. The concentration of negative ions is naturally higher around waterfalls and by the ocean; when water droplets are dispersed, an electrical charge is created. Research has proven the therapeutic values of salt caves and their positive influence in the treatment of respiratory diseases. The second factor is the open air salt water distillation pond is one meter deep & contains 17,000 cubic meters of water. 3 m diameter photovoltaic panels float upon the top surface of the pond via a custom pontoon system. Total PV surface area = 2,041 meters square. Photovoltaic pads are tethered to bottom of pond with enough slack to allow for random clustering. Panels are wired to the energy grid via tethered conduit.

Structural lattice: A pattern design for the structural system is created by tracing the planar surface deformation generated by the large wind tube openings. The result is a highly redundant structural lattice comprised of two layers per wall (one layer is shown). The layers are interconnected with lateral structural bracing via the wind tubes. The structural lattice is made with steel tubes that vary in diameter relative to overall member length. These tubes are sheathed in fiber reinforced polymer (FRP) material to protect against salt corrosion.



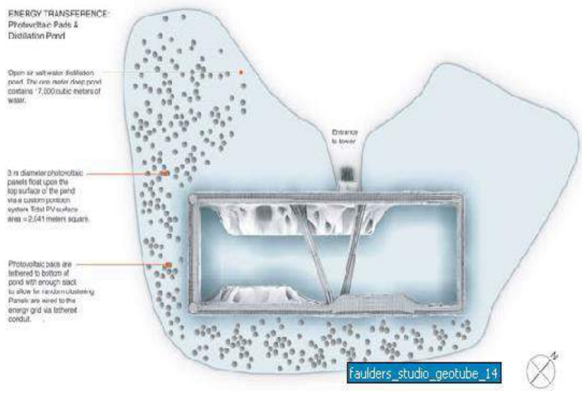


Fig.4 Geotube vascular system **sustainability system-energy transparence**
Geotube, Dubai by Faulders Studio , http:www.Faulders Studio.com (Photovoltaic pads, distillation pond)

4.2 Qatar national convention center, by jorge chapa:

The striking 177,000 square meter structure is seeking a LEED Gold Rating, a first for a building of its type in the region. When it's completed next year the center will boast 3,700 square meters of solar panels in addition to a host of other resource-saving features. The building's most iconic feature will be a massive steel representation of a Sidra Tree that supports the external canopy of the building and serves as its main entrance. **Materials and sustainability factors**: The building will feature 3,700 square meters of solar panels, which will provide around 12% of the building's total power. The choice to go with solar energy makes a lot of sense, granted the region's sunny arid climate. The center is also fitted out with occupancy sensors, water-efficient fixtures, LED lighting, carbon dioxide monitors, and variable air-volume systems that minimize the use of resources and improve the indoor air quality of the space. The previous systems are using type2 energy exchanging smart materials.

Fig.5 . **Qatar National Convention Center., solar panels as resource-saving features.,** www.inhabitat.com

4.3 Nano vent skin demonstrated in concept tower, Agustin Otegui's:

Materials: Nano Vent-Skin (NVS) … is a building skin that uses organic photovoltaics to capture sun and micro-wind turbines to capture wind. The outer skin of the structure absorbs sunlight through an organic photovoltaic skin and transfers it to the nano-fibers inside the nano-wires which then are sent to storage units at the end of each panel. Each turbine on the panel generates energy by chemical reactions on each end where it makes contact with the structure. Polarized organisms are responsible for this process on every turbine's turn. The inner skin of each turbine works as a filter absorbing CO2 from the environment as wind. NVS would be made in panels with sensors at each corner. If a micro-turbine breaks or fails, then the signal is sent through the nano-wires to the central system. Once the message gets to the central system, building material is sent through the central tube to regenerate the malfunctioning area with a self assembly process. **Sustainability factors**: NVS is just acting as a merger of different means and approaches into energy absorption and transformation, which will never happen in nature. (http://nanoventskin.blogspot.com/).

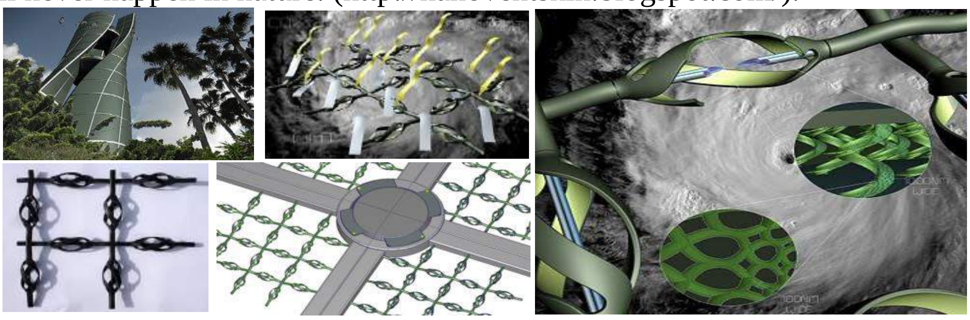


Fig.6 NVS interacting with Sunlight, Wind and CO2 -The outer skin of the structure absorbs sunlight through an organic photovoltaic skin and transfers it to the nano-fibers inside the nano-wires which then is sent to storage units at the end of each panel, http:www.xenophilius.files.wordpress.com

Photo-voltaic cells can be mounted on the building roof or integrated into the building façade this advanced smart material/ technology used successfully in many parts of the world.

4.4 Seoul commune 2026: gourd bottle tower matrix, Korea:

Seoul commune 2026 is located in Apgujongdong, a central area in the southern part of Seoul., Site Area: 393362 ㎡, Private Cells: 2590, The concept is based on a mixture of purely private rooms, so called 'cells', and communally used spaces.

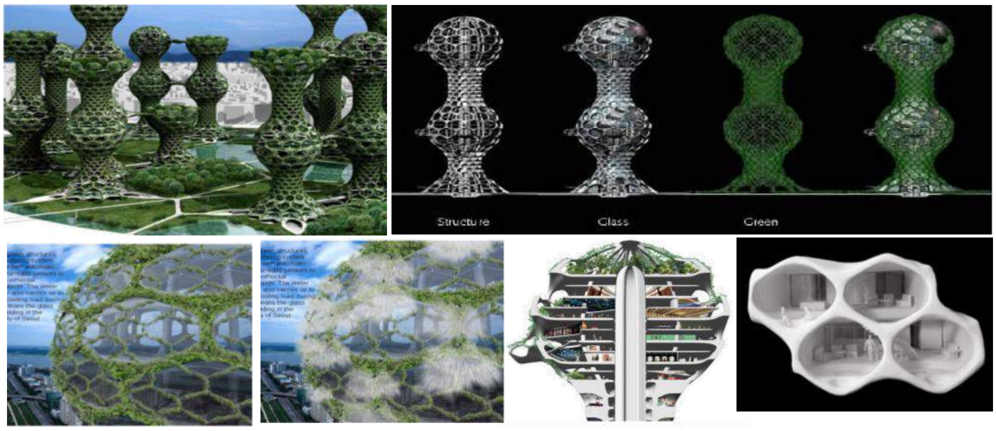


Fig.7 Seoul commune 2026: gourd bottle tower matrix**,** the viability of an alternative and sustainable community structure in the overpopulated metropolises , http://www.masstudies.com/

Materials and sustainability factors: The exterior skin of the towers consists of hexagonal lattice structures that derive from the unique spatial structure and create the unique appearance of the towers. The hexagonal openings are filled with various types of glass. Photovoltaic glass panels are placed in sunny areas for energy efficiency. Some exterior glass windows are recessed to create shaded balconies. The outer surface covering the lattice structure is made of a geotextile that creates an environment where vines can grow during the summer months to shade the openings. These integrated green structures have an internal watering system and a fog machine with automatic temperature and humidity sensors to optimize the environmental conditions of the plants. The water distribution system also carries up to 30 percent of the cooling load during the summer and cleans the glass windows of the building in the heavily polluted city of Seoul.

4.5 Shanghai world expo 2010, UK pavilion by Thomas Heatherwick:

UK pavilion is a six storey high object formed from some 60,000 slender transparent rods, which extend from the structure and quiver in the breeze. During the day, Each fiber optic rod is 7.5 meters long and encloses one or more seeds at its tip. During the day, they draw daylight inwards to illuminate the interior. At night, light sources inside each rod allowing the entire structure to glow. When the wind blows the optic "hairs" gently move as they create a dynamic effect for the viewers. Inside the darkened inner chamber of the Seed Cathedral" the tips of the fiber optic filaments form an apparently hovering galaxy of slim vitrines containing a vast array of embedded seeds. **Materials**: The Seed Cathedral is made from a steel and timber composite structure pierced by 60,000 fibre optic filaments, 20mm square in section, which pass through aluminium sleeves. The holes in the 1 meter thick wood diaphragm structure forming the visitor space inside the Seed Cathedral were drilled with great geometric accuracy to ensure precise placement of the aluminium sleeves through which the optic fibre filaments are inserted. This was achieved using 3D computer modelling data, fed into a computer controlled milling machine. For the sake of environmental protection, all materials used in “A Pavilion of Ideas” are recyclable. During Expo 2010, it will achieve the goal of zero carbon emission. (Environmental Report, Expo 2010 Shanghai China, 2009.6)

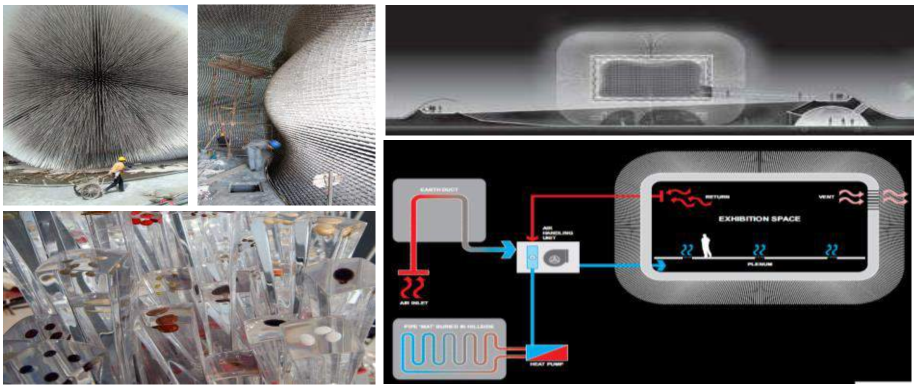


Fig.8 . UK pavilion**, the concept and energy efficient heat recovery air handling plant with pre-heat ducts,** http://www.akt-uk.com/

4.6 PV DUST -Designed for site in Abu Dhabi, on airport road near Masdar City:

PV (for Photovoltaic) Dust is a site-specific Land Art installation producing clean energy with astonishing efficiency. The first zero-carbon-footprint agglomeration in the world, next to Abu Dhabi airport, UAE. **Materials and sustainability factors**: PV Dust covers 175,000m2 of desert ground with a new breed of photovoltaic technology, aggregating into a cloud of energy-producing dust. The PV Dust cloud has an eerie presence, recalling the great desert sand storms of the gulf. Below the cloud, a network of sand-coloured gravel paths striates the territory. Seen from the flight path of incoming, airport-bound jets, the forking pathways assume the appearance of traditional Islamic lattices. Made of sand-colored gravel, Pebbles and crushed roof tiles, this landscape relies on a distinct desert palette and does not need to be watered PV Dust, the photovoltaic farm of the future, is made of 279 cubic modules of 25m*25m*25m featuring innovative, omni-directional PV technology. The modular PV Dust cloud could be resized to meet those needs**.**

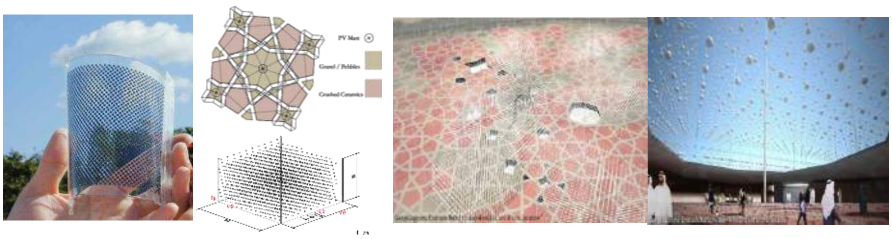


Fig.9, PV Dust, a proprietary spherical solar cell product developed by Kyosemi Corporation, Japan**.,** www.landartgenerator.org

4.7 Integrated concentrating (IC) dynamic solar facade, (CASE) center for architecture science and ecology:

(IC) Solar Facade System is a building integrated photovoltaic system that takes a dramatically different approach than existing building integrated photovoltaic (BIPV) or concentrating PV technologies to provide electrical power, thermal energy, enhanced daylighting and reduced solar gain. The IC Solar System produces electricity with a PV cell, captures much of the remaining solar energy as heat for domestic hot water, space heating (or, possibly, for distributed absorption refrigeration cooling), reduces solar gain by the building, and enhances interior daylighting quality, thus reducing overuse of artificial lighting. And requires little maintenance.

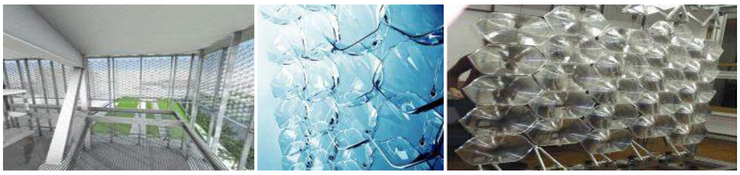


Fig.10, Integrated concentrating (IC) dynamic solar facade,
http://www.case.rpi.edu/projects/ICsolar.html

5. CASE STUDIES ANALYSIS AND INTERPRETATION:

Table.2. Case studies analysis based on material classification, building systems and using smart materials/ systems for sustainability.

Materials classifications Case study analysis		Geotube, dubai	Qatar national convention center	Nano vent skin demonstrated in concept tower	Seoul commune gourd bottle tower matrix	UK pavilion Expo 2010	PV DUST - Designed for Site in Abu Dhabi	(IC) Dynamic Solar Facade
Innovative materials	Recyclable Materials					■		
	Biodegradable materials	■						
	Biomaterials							
	Nonvariable materials					■		
	Functional Substances				■			
	Smart Materials						■	
	Hybrid Materials				■		■	■
	Functionally Gradient Materials							
	Nanomaterials			■				
Classification based on function/system	Traditional & High performance materials	■	■			■		
	Smart Materials							
	Smart devices and systems		■	■				■
	Intelligent environments				■			
Smart material as adaptive system	property-changing					■		
	energy-exchanging	■	■	■	■		■	■
Building System	Control of solar radiation transmitting through the building envelope		■	■	■		■	
	Control of conductive heat transfer through the building envelope							
	Control of interior heat generation							
	Energy delivery	■		■			■	■
	Optimization of lighting systems		■					■
	Optimization of HVAC systems	■	■	■	■			
	Control of structural systems					■		
Using smart materials/ systems for sustainability	Low energy	■	■	■	■	■	■	■
	Low cost		■				■	■
	Design with nature	■	■		■		■	
	Sustainable construction material, system & technologies	■	■	■	■	■	■	
	Building envelopes and innovative Façade systems	■	■	■	■	■		■

From the mentioned above analysis, in part one table has shown that most of examples using photovoltaics (PVs) as representative applicable smart material which has resulted in a greater impact on energy-saving, in part (2) using building system in relation to potentially applicable smart materials, leading to optimization of the energy produced by the system, using materials suitable for the intervention and assessing the context in which they must operate, In part (3) Smart material/ Technology has been used to improve the ecological performance of the building, such as the increase of energy efficiency or the adaptive control of the building with regard to the changing environmental conditions, therefore supporting sustainability.

6. Conclusion:

Smart materials will have an increasing range of applications and the underlying sciences in world. It must be maintained at a standard which helps achieve technological objectives which mean that smart materials and system must solve engineering problems and provide an opportunity for new wealth creating products and could have an important role in sustainability architecture.

From the data collected in this research regarding material function/system, this will speed the development of new materials for use in different applications. Smart materials and systems are able to sense and respond to the environment around them, they have the potential to improve existing technology and add new functionality to products. In other words they are considered a new way to bring nature into architecture. In addition, smart materials are considered as “building envelope of the future” that combines various wall functions into a single product. The Smart Materials/ technologies provide an opportunity to develop a new building aesthetics.

The real benefit of smart materials is for sustainability. The materials take energy directly from the environment so they do not necessarily need to be on the grid. Smart materials are both the “sensor” and the “actor”. In order to be fully aware of the smart material, architect should know the advantages of this material/technology that include these words or meanings: information, surface, nano, energy, light and climate.

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