Nanomaterials and its Impact on the Quality of the Internal Environment for Sustainable Interior Design

Researcher. Manal Masoud Ahmed Al-Maliki

Lecturer in Department of Interior Design, College of Designs and Arts - University of Tabuk

m-almalki@ut.edu.sa

Abstract:

Nanotechnology, the key technology of the 21st century, is making inroads in interior design. It opens up new possibilities in sustainable interior design through nanomaterials, nanomaterials can be used as coatings, insulators, air purification or in the manufacture of other products, and will have a major impact on how public spaces are thought of for interior design such as hospitals, offices, restaurants, hotels and malls and offer unparalleled performance in durability, energy efficiency, economy and improving the quality of the internal environment to achieve sustainability.

The Research problem is related to the question of how interior designers' use nanomaterials to achieve the quality of the internal environment and achieve the standards of sustainable interior design. and the aim of the research is to know the positive benefits of nanomaterials in interior design and furniture, and to know the effect of using nanomaterials in improving the quality of the internal environment to achieve sustainable interior design. The research follows the descriptive analytical approach, this paper provides an overview of the applications of nanomaterials for interior design with an analysis of these examples, and an explanation of the impact of nanomaterials on sustainable interior design, followed by some conclusions and recommendations.

Keywords:

Nanotechnology – Nanomaterials - Internal Environment- Sustainability- Sustainable Interior Design.

الملخص:

تعتبر تقنية النانو هى التكنولوجيا الرئيسية للقرن الحادي والعشرين ، وإنها تحقق نجاح في التصميم الداخلي وسيكون لها تأثير هائل على طريقة تفكير المصممين الداخليين. سوف يتم فتح إمكانيات جديدة في التصميم الداخلي المستدام من خلال خامات النانو ، ويمكن استخدام خامات النانو كطلاءات أو في العزل الحراري أو مواد لتنقية الهواء أو في خلايا الطاقة الشمسية أو في تصنيع منتجات أخرى كثيرة ، وسيكون لها تأثير كبير على كيفية تفكير المصمم في التصميم الداخلي للأماكن العامة مثل المستشفيات والمكاتب والمطاعم ، والفنادق والمراكز التجارية وتقدم أداءً غير مسبوق في المتانة وكفاءة الطاقة والاقتصاد وتحسين جودة البيئة الداخلية لتحقيق الاستدامة .

ترتبط مشكلة البحث بمسألة كيفية استخدام المصمم الداخلي لخامات النانو لتحقيق جودة البيئة الداخلية وتحقيق معايير التصميم الداخلي المستدام. والهدف من البحث هو معرفة الفوائد الإيجابية للمواد النانوية في التصميم الداخلي والأثاث ، ومعرفة تأثير استخدام المواد النانوية في تحسين جودة البيئة الداخلية لتحقيق تصميم داخلي مستدام. يتبع البحث المنهج الوصفي التحليلي ،

ويقدم هذا البحث لمحة عامة عن تطبيقات خامات النانو في المباني والتصميم الداخلي لها مع تحليل هذه الأمثلة ، وشرح تأثير خامات النانو على التصميم الداخلي المستدام ، متبوعة ببعض الاستنتاجات والتوصيات.

الكلمات المفتاحية:
تقنية النانو - المواد النانوية - البيئة الداخلية - الاستدامة - التصميم الداخلي المستدام.

Introduction:

Nanotechnology is one of the new emerging technologies of the contemporary time, as a result of the international focus on nano sciences. Such technology has made it possible to manipulate the matter on an atomic basis; this is expected to transform and revolutionizes the way of live. The nano world is a convergence of a real mix of scientific and technological.

The applications of nanotechnology include almost all aspects of the life, in medicine, industry, communications, building façades, and interior design. Nanotechnology offers ways to create smaller, cheaper, lighter and faster devices that can do more and smarter things, use less raw materials and consume less energy.

The application of nanotechnology in architecture and interior design is wide and varies, especially in materials selection, which will not only be reflected on the design, but also has a great impact on the methodology of thinking of interior designers, according to the new vast options that the nanotechnology offers.

It may change the way the interior designer thinks of the forms to design internal building, and help to combat the pollution. It offers a variety of applications, either in designing new materials with new properties, nano-sensors that can help inspect the surrounding environment.

There are nano-coatings which can repel dirt and reduce the need for harmful cleaning agents, or prevent the spread of hospital-borne infections and improve indoor- air quality.

Following research presents a background on nanomaterial and explain its role in reduce energy, followed by some examples of applications of nanomaterials in interior design.

Research problem:

The Research problem is related to the question of how interior designers' use nanomaterials to achieve the quality of the internal environment and achieve the standards of sustainable interior design in their design solutions.

Research objective:

The aim of the research is to know the positive benefits of nanomaterials in interior design and furniture, and to know the effect of using nanomaterials in improving the quality of the internal environment to achieve sustainable interior design.

Research Methodology:

The research follows the descriptive analytical approach by studying and analyzing some applications of nanomaterials in interior design. And clarify the impact of the use of nanomaterials on improving the quality of the internal environment and its impact on sustainable interior design.

1- Sustainability:

We must act to safeguard our own survival and sanity by ensuring that humans always have access to food, energy, clean water and the natural world. In parallel, we arguably have a duty to protect ecosystems and other species, since we have caused the problems, and we alone have the intelligence, communication skills and knowledge to solve them.

The key to solving these problems is sustainability, or meeting today's needs without compromising those of the future. In the construction industry, this needs to be brought about through sustainable design, which applies this principle to all design decisions. While sustainability has social, economic and environmental aspects. [10]

Fig.1, shows the three principles of sustainability

1-1- Sustainable design:

Sustainable design considers the big picture: the need to transform global settlement and industrial patterns to be healthier and less wasteful, less impactful on the natural environment. It brings these concerns down to the scale of each building, each site plan, each choice of materials and processes.

A building just feels right on the site rather than obtrusive; there is abundant daylighting; nature is both within and outside; as a design element, water flows naturally from the building into a bioswale or other natural drainage feature; the building is comfortable without a huge rush of moving air; internal

spaces create expansiveness and delight; and the overall effect is beautiful. As many scientists have noted, if the solution to a problem is not "elegant," it is either incorrect or there is probably a simpler solution waiting to be found. [5]

1-2- Elements of sustainable building and interior design practice include:

• High levels of resource efficiency overall, including transportation and energy use in building materials, construction and building operations.
• Energy-efficient building systems.
• Renewable energy use.
• Water conservation and graywater reuse.
• Use of natural energies for building heating and cooling.
• Rainwater capture, reuse and recycling.
• Use of recycled-content, non-toxic, and local materials.
• Healthy and productive indoor environments for people.
• Durability of building materials and designs.
• Flexibility for building uses to change over time.
• Access to alternative transit modes. [5]

1-3- Sustainable Building Concepts:

sustainable buildings can be defined as "those buildings that have minimum adverse impacts on the built and natural environment, in terms of the buildings themselves, their immediate surroundings and the broader regional and global setting. [3] " The action of sustainable buildings may be defined as building practices which strive for integral quality (including economic, social and environmental performance) in a broad way. Thus, the rational use of natural resources and appropriate management of the building stock will contribute to saving scarce resources, reducing energy consumption, and improving environmental quality. [9]

1-4-Sustainable Design Objectives:

Five main goals for sustainable buildings are defined as follows:

- Efficient use of resources
- Energy Efficiency
- Reduce pollution
- Harmony with the environment
- Integrated and Systemic Approaches

To achieve this, sustainable buildings must be energy and resource efficient (including reducing greenhouse gas emissions), not wasted and non-polluting, and highly resilient and adaptable for long-term functions. It should also be easy to operate and maintain, and supportive of occupant productivity and well-being (including good indoor air quality and reduced noise). To put goals into practice and evaluate a building's performance, the following categories of standards are often used:

- Sustainable site
- Energy efficiency and renewable energy
- Water conservation
- Materials and waste management
- Indoor environmental quality. [9]

2-1-Nano scale:

The nanoscale, based on the nanometer (nm) or one-billionth of a meter (10^{-9} m), exists specifically between 1 and 100 nm as shown in (Fig.2). General sense, materials with at least one dimension below one micron but greater than one nanometer can be considered as nanoscale materials [3].

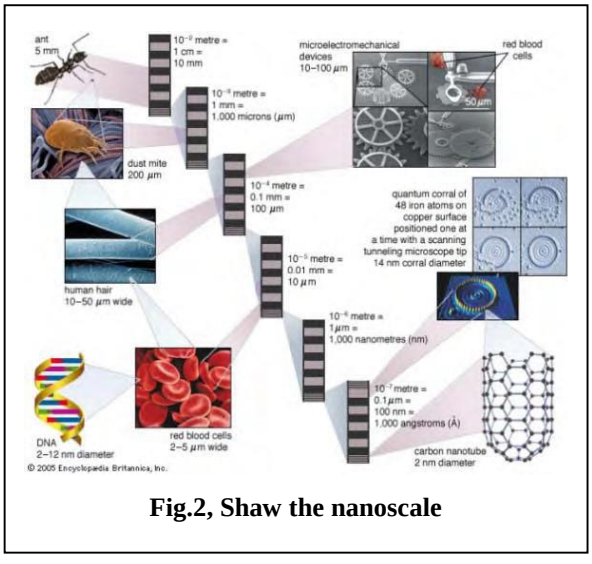

Fig.2, Shaw the nanoscale

To properly appreciate the diversity of nanomaterial, some form of categorization is required. The most typical way of classifying nanomaterial is to identify them according to their dimensions [5], one-dimensional (1-D), two dimensional (2-D), and three-dimensional (3-D), Table 1, This classification is based on the number of dimensions confined to the nanoscale range (<100 nm). As categories of nanomaterial.

Table 1: A Nanomaterial is an object that has at least one dimension in nanometer scale [1].

Nanomaterial Dimension	Nanomaterial Type	Example
One dimensions <100 nm	Thin Solar films, layers and coatings.	
Two dimensions <100 nm	Nanotubes, Nanowires, fibers.	
All three dimensions <100 nm	Nanoparticles, nano rings, nano shells, microcapsules.	

2-1-1- One-dimension: thin films, layers and surfaces:

One-dimensional Nanomaterials have been developed and used for decades in fields such as electronic device manufacture, chemistry and engineering, Fig.3.

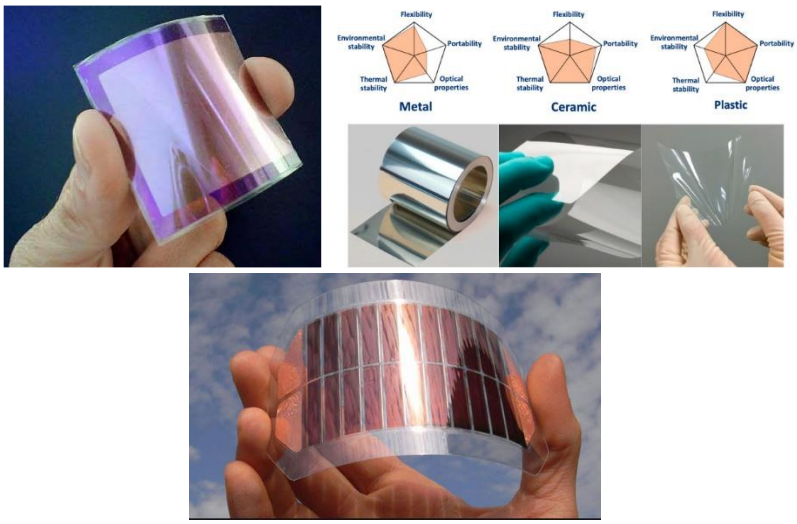

Fig.3, Thin Solar film,1- dimension nanoscale. [11] [12]

2-1-2-Two-dimension nanoscale: tubes and wires:

• Carbon nanotubes (CNTs) are extended tubes of rolled graphene sheets. They are mechanically very strong, flexible (about their axis), and can conduct electricity extremely well. CNTs are used in in reinforced composites, sensors, nanoelectronics and display devices [6]. Fig.4

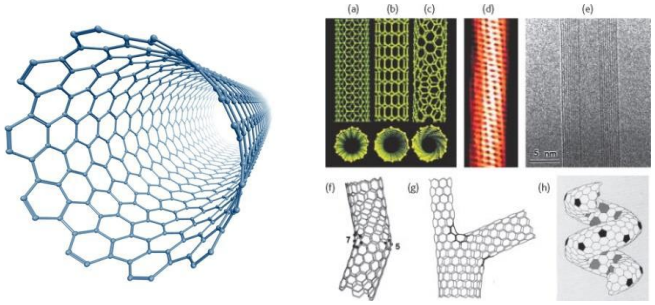

Fig.4 CNT structure 2-dimension nanoscale. [16]

2-1-3 Three-dimension nanoscale: nanoparticle nano rings, nano shells, microcapsules:

• Nanoparticles are often defined as particles of less than 100nm in diameter. They exhibit new properties (such as chemical reactivity and optical behavior) that compared with larger particles of the same materials. Titanium dioxide Tio2 and zinc oxide become transparent at the

nanoscale, however are able to absorb and reflect UV light, and have found application in sunscreens. Fig.5, For most applications, nanoparticles will be fixed, for example attached to a surface or within in a composite. [1]

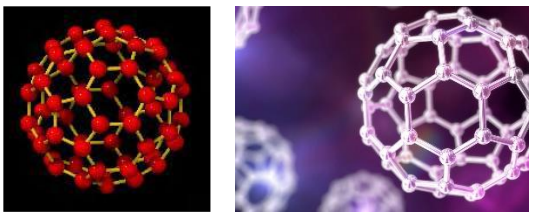

Fig.5, Nanoparticle 3- dimension nanoscale. [17]

2-2-Nanomaterial in architecture and interior design:

it is expected that nanomaterial and nanotechnology will play an increasing role in the architectural and interior design. Dozens of building and interior design materials incorporate nanotechnology, from self-cleaning windows to flexible solar panels, Wi-Fi blocking paint, self-healing concrete, materials to block ultraviolet and infrared radiation, smog-eating coatings, and light-emitting walls and ceilings. Nanotech is also starting to make the "smart home" a reality, which enables sensors to monitor temperature, humidity, and airborne toxins.

The use of nanomaterial in architecture and interior design will present new opportunities to solve problems by improving significantly the nature of building structure and efficiency and the way buildings relate to the environment .

Nanomaterial can expand design possibilities for both interior and exterior spaces. Their use can open up new possibilities for sustainable design strategies. [8]

These nanomaterials can add functional characteristics and novel sensing properties such as, increased self-cleaning capacity, fire resistance, and many other capacities like heat absorbing windows and energy coatings taking building materials (coatings, panels and insulation) to a maximum capacity of performance in terms of energy, light, security and intelligence [8].

The most compelling advantage for using nanomaterials in architecture and interior design is for greater energy efficiency. Nanotechnology and nano materials offer a new technological means with which to tackle climate change and help reduce greenhouse gas emissions.

2-3-Nanomaterials applications and Functions:

The use of nanomaterials in architecture and interior design is strongly linked to sustainability, to improve energy efficiency and reduce greenhouse gases. Architects and interior designers are to find innovative solutions for climate changes, by combining ambitious architecture with energy efficiency [9].

The use of materials and surface properties that have now become possible through nanotechnology offer architecture, and interior design a mean of achieving greater energy efficiency and sustainable interior design through innovations.

Following are some examples of the application of nanomaterials in various aspects of interior design, including coatings, insulations, air-purification, fire-proof and scratchproof.

The most field influenced by nanotechnology in architecture and interior design is Nanomaterials.

2-4- Applications of Nanomaterials in interior design:

2-4-1- Coatings:

Coatings (Finishing Materials) are an area of significant research in nanotechnology in interior design and work is being carried out on concrete, glass, wood and steel.

Coatings are thin coverings that are deposited on a base material to enhance its surface characteristics or appearance [7]. These surfaces can for example be superhydrophobic (the fluids reach the surface to form beads and run down).

The main advantages of nanocoating are :better surface appearance, good chemical resistance, decrease in permeability to corrosive environment and hence better corrosion properties, increase in modulus and thermal stability, easy to clean surface, anti-fogging, anti-fouling, anti-skid, better retention of gloss, better thermal and electrical conductivity and other, mechanical properties like scratch resistance, anti-reflective in nature , chromate and lead free, good adherence on different type of materials.[13]. Nanocoating's are versatile and can be used almost anywhere: Self-Cleaning, Lotus-Effect, Self-cleaning: Photocatalysis, Easy-to-clean (ETC), Antibacterial….etc.[2].

The leaves of Lotus plants are coated with minute wax crystals around 1nm in diameter which repel water; droplets falling onto them bead up and, if the surface slopes slightly, will roll off. Lotus effect is one of the best-known means of designing surfaces with Nanomaterials. Self-cleaning behavior is normally achieved using hydrophobic surfaces with nanostructured features fig. 6. These surfaces are inspired by the Lotus flower leaves that combine a surface roughness at the nanoscale and water repellent wax. It can be mimicked, using nanocomposite materials made up of nanoparticles in a polymeric matrix [13].

Fig. 6 Lotus plant, a microscopic view of a water droplet resting on a super hydrophiid knobby surface and how the basic principle of the Lotus-Effect works

a- Nano-coating paint self-cleaning Lotus-Effect:

The first commercial product made was a silicone resin house paint which has since become widely used and in which silicon nanoparticles form micro-structured surface [13]. Nanocoating's can be anti-graffiti, anti-static, anti-mist or anti-glare or they can block UV light [18].

As an example, using coatings self-cleaning Lotus-Effect, in facades of housing, Hamburg, Germany, Fig. 7 the differentiated coloring of the new facades is most apparent. Warm colors in a palette between yellow and red lend the entire estate a pleasant and unified appearance.

Fig. 7 Strucksbarg housing façade, Hamburg, Germany.[6]

- Nano-coating for Wood:

Provides complete protection against sunlight and moisture. It preserves the natural look of the wood and is resistant to extreme environmental conditions such as very cold weather. It repels pests and can be applied to surfaces both old and new in a simple, convenient and efficient application [4]. There are many ways for Nano coating Wood.

Water-repellent wood: For wood Furniture, walls and similar surfaces; we can apply nano wood sealant to saturation by spraying, or with brushes and paint brushes. Sealant is fabricated from silicone, wax and oil [19]. By creating nanostructures similar to those of the Lotus plant on the surface of the wood, the contact area between water & wood is minimized and surface adhesion reduced. Water rolls off instead of penetrating the wood [6]. Fig. 8

Fig. 8, shows the Water-repellent wood and the Self-Cleaning Wood [19].

- Nano-coating floor:

Nano floor sealant for absorptive surfaces and Nano floor sealant for slightly and non-absorbent surfaces protect against soiling due to wet, and oil. Floor sealer for porous surfaces is free from silicone, wax and oil. Sealants are prepared in such a way that the coated surface retains its natural color and diffusion, resists water [20].

b- Self-Cleaning: Photocatalysis coatings:

Photocatalytic self-cleaning is the property of surfaces coated with titanium dioxide (TiO2) nanoparticles. Its properties are super-hydrophilic of the surfaces which are created by oxygen gaps on the TiO2 surface. Deposited dirt is broken down and lies loose on the surface, a water film washes dirt away. For the function to work, UV light, oxygen and air humidity are required

and reduces maintenance requirement. Fewer detergents are required, resulting in less environmental pollution and less wear and tear of materials. [4]

UV light present in normal daylight is sufficient to activate the photocatalytic reaction fig. 9. Organic dirt on the surface of a material is decomposed with the help of a catalyst.

Photocatalytic surface coatings are applied to façade panels made of glass or ceramics or to membranes, its more effective outdoors than indoors [6].

It helps reduce environmental pollution in interior design and can be used in restaurants, schools, apartment buildings, hospitals, etc.

Fig. 9, show organic dirt and grime is broken down and" decomposed". UV light, present in sunlight, is necessary to initiate photocatalysis. When water impacts on the surface, it spreads to form a film washing away the loose dirt. [6].

Fig.10, show the use of self-cleaning function of the glass is therefore especially useful for hard-to-reach locations such as overhead glazing or glazed external walkways [1].

c- Easy-To-Clean (ETC) coatings:

Easy-To-Clean surfaces are water- repellent and are often confused with other self-cleaning functions such as the Lotus-Effect but surfaces are smooth rather than rough. It is also often confused with other photocatalytic self-cleaning functions but surface coatings do not require UV light to function and their hydrophobic surface properties - as opposed to hydrophilic - cause water to run off in droplets rather than forming a thin film of water [6]. It does not mean that a surface with this treatment never needs to be cleaned, however the amount of cleaning required compared with that of traditional products can be reduced.

Fig. 11 show the use of Easy-to-clean (ETC) Science to Business Center Nanotracks & Bio, Marl, Germany. [1].

d- Antibacterial coatings:

In interior design of hospitals, all surfaces are areas particularly susceptible to germ transmission but also are suitable candidates for antibacterial surface coatings, whether enclosing surfaces such as floors, walls and ceilings or furnishing such as textiles, sanitary installations, shelves and worktops, and in particular knobs, buttons. [1]

With the help of silver nanoparticles, it is possible to manufacture surfaces specifically designed to be antibacterial or germicidal. Whether in the form of ultra-thin and invisible coatings or materials to which the particles have been added, these have an effect stronger than antibiotics. The antibacterial effect of silver results from the ongoing slow diffusion of silver ions. The very high surface area to volume ratio of the nanoparticles means that the ions can be emitted more easily and therefore kill bacteria more effectively. [6]

Fig. 12, show the use of antibacterial coatings in interior design of hospitals [6].

Fig. 13 show the use of antibacterial coatings surfaces based on silver nanoparticles in coating of furniture. [6].

f- Air purifying:

The use of Nanomaterials is possible to improve the quality of air. It enables unpleasant odors and pollutants to be eradicated (Sustainable Environment). It does not replace ventilation, but improves air quality.

Nanotechnology makes it possible to chemically decompose odors into their harmless constituent parts. Here the molecules are cracked, giving off steam and carbon dioxide. Air-

purifying curtain materials can simultaneously be equipped with antibacterial properties fig.14. Air purification technology is increasingly being used for textiles and paints [4].

To function adequately, the air-purifying surface area must be sufficient with regard to the volume of the room. Only surfaces that are exposed to the air, i.e. those not concealed by furniture, are relevant. For processes based on oxidative catalysis, normal air circulation is sufficient. Nicotine or formaldehyde molecules can also be cracked and filtered out of the indoor air. [6]

Fig.14 show the use of air purifying coatings nanomaterials in interior design

2-4-2 -Thermal insulation by nano materials:

Nanogel (Aerogel) :

Nanogel (Aerogel) currently holds the record as the lightest known solid material and was developed back in 1931.

The gel is a globular granulate and appears milky, translucent and somewhat cloudy. It is simply an ultra-light aerated foam that consists almost 100% of nothing other than air (the exact figure varies between 95% and 99.9%). The remaining foam material is a glasslike material, silicon dioxide, also known as silica. The nano dimension is of vital importance for the pore interstices of the foam: the air molecules trapped within the minute nanopores - each with a mean size of just 20 nm - are unable to move, lending the aerogel its excellent thermal insulation properties. In addition to its thermal insulating properties, aerogel also acts as a sound insulator according to the same basic principle. [6].

It is used as an insulating fill material in various kinds of cavities – between glass panes, U-profile glass or acrylic glass multi-wall panels – and is therefore well suited for use in external envelopes of buildings. That way aerogels can help reduce heating and cooling costs significantly.

Because it is translucent, aerogel exhibits good light transmission, spreading light evenly and pleasantly. [1]

Fig. 15, show the translucent nanogel granulate, the use of aerogel in the windows in School extension, London, England [1]

2-4-3- Energy coating (for green building):

Similar to the way a plant absorbs sunlight and turns it into chemical energy to fuel the growth of a plant, energy coatings absorb sunlight and indoor light and convert them into electrical energy [2].

a-Thin film solar:

Thin-film solar technologies often use no silicon semiconductor materials including copper, indium, gallium and selenium (CIGS) to create photovoltaic cells that convert sunlight into electricity [2]. Nano solar produces thin- film solar cell that can be integrated into buildings facades. It makes integrating solar into a building more like printing a newspaper, a major advance from glass plates that are installed on rooftops. Solar sheets can be made for less than a tenth of what current panels cost at a rate of several hundred feet per minute. Its Solar Ply BIPV panels, made from semiconductor quantum dots and other nanoparticles, will create solar-electric "carpet" to be integrated into commercial roofing membranes [4].

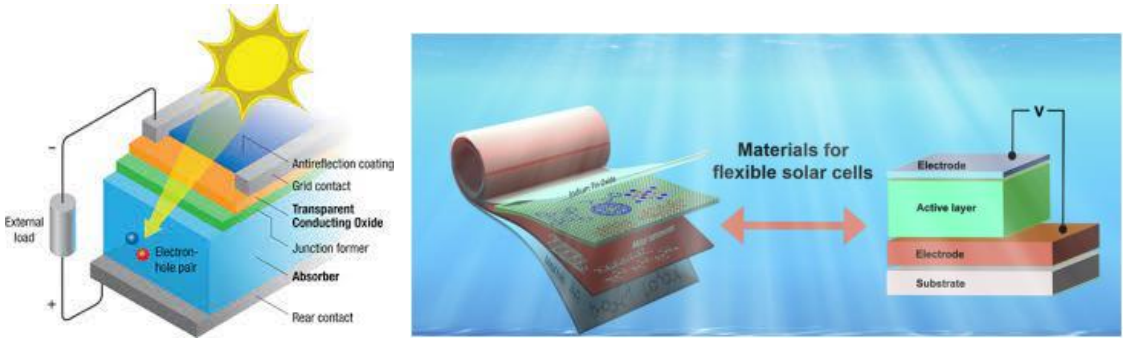

Fig. 16 show the Thin-film solar [11], [12].

b- Solar protection glass:

The advent of nanotechnology has provided a new means of integrating electro chromatic glass in buildings. The primary difference to the earlier product is that a constant electric current is no longer necessary. A single switch is all that is required to change the degree of light transmission from one state to another (from transparent to darkened). and this glass gives protection and privacy and control the degree of transparency and opacity and improve thermal insulation and protection against ultraviolet waves [4].

Photochromatic glass is another solution for darkening glass panels. Here the sunlight itself causes the glass to darken automatically without any switching.

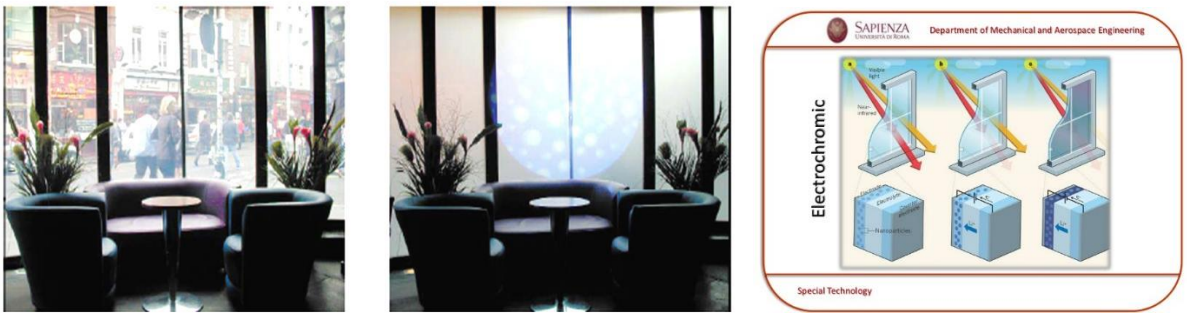

Fig. 17 show the use of Solar protection glass in the windows

2-5-Nanomaterials Can Make a Concrete Contribution to The Following Areas:

• Optimization of existing products.
• Damage protection.
• Reduction in weight and / or volume.
• Reduction in the number of production stages.
• A more efficient use of materials.
• Reduced need for maintenance (easy to clean, longer cleaning intervals) and / or operational upkeep. [1].

And as a direct result:

• Reduction in the consumption of raw materials and energy and reduced CO2 emissions that will affect good in environment.
• Conservation of resources.
• Greater economy.
• Comfort.

Thus, its help to prepare the thermal environment and the well quality of the interior space and achieving sustainability. [6]

3-1-Sustainable Nano-Architecture:

The use of nanotechnology offers environmental and economic advantages for the conservation of resources and Rationalization of energy consumption.

Technologies that help reduce climate change are in demand more than ever before. In future, environment and the economy will become inseparably connected.

Environmentally friendly production methods and materials, Rationalization of energy consumption, reduced environmental pollution and the conservation of resources are chances which nanomaterials offers. [7].

Sustainability is essential; buildings are often planned with 20- 30-year cycles, which can make it difficult to incorporate coatings with 2-3 years durability. There are, however, some firms that provide a 10-year guarantee for their nanotechnology-based products.

Production processes can also be made more efficient and more cost-effective with the help of nanotechnology, by reducing the amount of energy and raw materials required to a minimum [8].

Nanotechnology revolution is bringing dramatic improvements in building performance, energy efficiency, environmental sensing, and sustainability, leading the way to greener buildings .

The nanotech and building sector have to get to know each other a lot better in order to realize the dramatic benefits awaiting each of them .[9]

It should explain the economic opportunities in Green Building Design, Construction and Operation and demonstrate to architects, interior designers, and others in the $1 trillion per year global building industry that nanotechnology and nano materials have a lot of healthful benefits for people and the environment [8].

3-2-Nanomaterials and sustainable interior design:

The most compelling argument for using nanotechnology and nanomaterials in architecture and interior design is for conservation of resources and greater energy efficiency.

Nanotechnology offers a new technological means with which to tackle climate change and help reduce greenhouse gas emissions.

The use of Nanomaterials in construction is strongly linked to sustainability witch three pillars are social, environmental and economic sustainability [6].

Nanotechnology is an enabling technology that is opening a new world of materials functionalities, and performances. and it is also opening new possibilities in construction and interior design sustainability.

it can lead to a better use of natural resources materials, obtaining a new characteristic with minor material use.

It can also help to solve some problems related to energy in building and interior design like generation Renewable energy and reduce consumption. [4]. Energy can be conserved using Nanogel (Aerogel) thermal insulation.

Also, nano materials can save energy through the use of thin film solar and Solar protection glass, and the indoor environment can be maintained without pollutants by using Antibacterial coatings to keep the user healthy from bacteria and microbes.

Conclusions:

The nanotech revolution can bring dramatic improvements in building performance, energy efficiency and sustainability to building projects, thus nanoarchitecture will be the upcoming new architectural trend of the contemporary time and will be a key contributor in the creation of a more sustainable society.

2. More for less: Nanomaterials is about getting more function on less space. Efficiency and getting more with less are essential for sustainability

3- Nanomaterials are materials made from nanometer-scale substances has opened up possibilities for new and innovative functions in sustainable interior design.

4. Nanotechnology are the development of Products, and It produces nanomaterials and products Preserve the environment and human health, like nanobacteria, and produces nano-products that provide solutions to environmental problems.

5- Nanomaterials offers the possibility of great advances whereas traditional approaches and materials, at best, offer only incremental improvements.

6-Nanomaterials help with thermal insulation and reduce ultraviolet rays, thus helping to prepare the thermal environment and the quality of the interior space.

Recommendations:

1- Interest in nanotechnology science and nanomaterials education that a nanotechnology course must soon be required in most interior design, curricula to achieve the benefits gained from it economically, environmentally and socially.

2- designers have to be able to define the performance criteria they are looking for like sustainability and then have materials designed to meet these criteria.

3- They have to propose alternative material studies to their organization, or to suggest projects involving sustainable and nanotechnology principles.

4- They must read and get on the internet and investigate the development of new materials and new properties.

References:

Enrico Ercolani, Nano Materials for Architecture, Material Science and Technology, by Department of Industrial Engineering, Universta de Roma, Italy. P 15

http://didattica.uniroma2.it/assets

1- Fahd Abd Elaziz Hemeida, Green Nanoarchitecture, Master thesis, faculty of Engineering, University of Alexandria, 2010.

2- Hasegawa, T., 2003. Environmentally Sustainable Buildings: Challenges and Policies, OECD, Paris.

3- Inas Hosny Ibrahim Anous, Nanomaterials and their applications in interior design, American International Journal of Research in Humanities, Arts and Social Sciences, 7(1), June-August, 2014, pp. 16-27 2014.

4- Jerry Yudelson, Green Building A to Z, understanding the language of green building, Canada. 2007.p.165

5- Leydecker, Sylvia. Nano Materials in Architecture, Interior Architecture and Design. Birkhauser Verlag AG, Berlin, 2008.p.18

6- Michael F. Ashby, Paulo J. Ferreira, Daniel L. Schodek. Nanomaterials, Nanotechnologies and Design. An Introduction for Engineers and Architects, Elsevier Ltd, 2009.

7- Mohamed Atwa , Ahmed Al-Kattan and *Ahmed Elwan, Towards nano architecture: nanomaterials in architecture-a review of functions and applications. p 3553

International Journal of Recent Scientific Research Vol. 6, Issue, 4, pp.3551-3564-, April,

2015

8- Sam C. M. HUI, Sustainable Building Techniques for Hot and Humid Climates, DR. Department of Mechanical Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong, China,2007.

9- Sian Moxon, Sustainability in Interior Design, Laurence King Publishing Ltd, London, 2012p. 14

10- https://www.azonano.com/article.aspx?ArticleID=3068

11- https://www.metallurgyfordummies.com/what-is-thin-films-materials.html

12- http://www.nanotechnology-solutions.com/nanotechnology-lotus-effect.php

13- http://www.nanotechnology-solutions.com/nanotechnology-windows-sealing.php

14- https://www.nanowerk.com/spotlight/spotid=50063.php

15- https://www.sciencedirect.com/science/article/pii/S1369702109701762

16- https://www.shutterstock.com/search/nanoparticles

17- http://www.nanoandme.org/nano-products/paints-and-coatings

18- http://nanotechcanada.ca/products.html

19- http://www.nanotechnology-solutions.com/how-nanotechnology-sealing-works.php