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Transparent Glassy façades saving energy inside buildings: Mini review

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Abstract:
This survey is for a collection of researches using nano-phase glass to control the proportion of light and heat from entering buildings through windows. It was found that there are many ways to control the entry of light and heat into buildings, whether positive or negative. We mentioned some in this survey but in this review, we focus on the glass containing the nano-phase. we focus in this survey most of the additives that can be obtained from the nano-phase, the percentage of blocking, and its effect, whether positive or negative.

Introduction:

The main materials in the manufacture of windows are glass, and to achieve the degree of its isolation and saving energy inside buildings, it can be achieved by changing its color changing the degree of transparency, changing the degree of thickness, double plates, or handle it in any way to get the best performance ever.

Our scan is to determine most of the research that has been interested in studying the properties of glass with nano phase that change its characteristics to achieve the modern and high technology requirements in latest times[1].

I. METHODS OF SAVING ENERGY IN BUILDINGS

Lighting buildings

Lighting saves energy through day, there is an interest in natural lighting, the solar energy worthy source freely available daily. Electrical lighting in houses is a big part of energy consuming in buildings and can be reduced by depending on Sun lighting. Consequently the releasing of CO_2 and other gases that make greenhouse phenomena can be reduced. Earth warming can be reducing by the dependence mainly on the sun lighting [2].

The amount of sun lighting is changed with seasons through year day and night and according to the atmosphere. The negative response of the building to daytime lighting can enhance comfort as it has a significant therapeutic effect. The use of appropriate passive design systems ensures that you quietly invite natural light, while keeping homes or workplaces heated and saving energy with free, low-cost energy. There are some areas in buildings where daylight cannot reach and electric light will always be needed. With advances in technology, in places where there are restrictions on the use of natural light, solar light tubes or sky tubes are good alternatives to maximize daylight, reflector and tube reflection technology makes the amount of incoming light very usable. From another point of view, natural light is part of our biological needs. With properly installed and maintained daylighting systems, natural light is a vital need for the quality health, productivity, and safety of building occupants. The pleasant environment generated by natural light reduces stress levels for workers. Productivity increases as worker health improves; With better productivity come financial benefits for employers. Maximizing its use will not only help you turn off the lights during the day, but will save you money by the minute [3]. The negative effect of lighting: the penetration of light from a window into a building is approximately 5 meters, and the space located far from natural light is more than is considered insufficiently lit. Windows and lighting have been considered in different ways in the history of building design, considering environmental issues and cost savings. To achieve energy efficiency, daily lighting has been used for lighting purpose as it is estimated that 30-50% of energy cost in office buildings is spent on lighting.

Different types of ultra violet radiation (UVR) emitted from the sun; ie. (a) UVA which makes up approximately 95-97% of the UVR reaching earth, penetrates the skin and can contribute to skin cancers; and (b) UVB which causes sunburn but also enables the synthesis of Vitamin D. Spending some minutes outdoors every day with skin exposure to direct light is sufficient for the human body to synthesis healthy levels of Vitamin D. While glass (windows) reduce UVB radiation significantly (by approximately 95%), receiving this though glass over a longer period of time is preferable to not receiving it at all. Boubekri suggests that people are not exposed to sufficient sunlight; even in weather enjoying long sunlight hours and that the good quantity of sunlight people require may be established. The lack of Vitamin D can cause of, or being in, many other ailments including cancers other than melanoma, sclerosis, psoriasis, hypertension and some cardiac abnormalities.

Thermal effect

How much heating and cooling a house requires depends on: the weather outside (temperature, humidity, wind and sunshine), the building materials and the other heating objects inside houses.

If the sun is lighting on a window, buildings absorb some heat from that sunshine depending on the strength of the sunrays, the angle of incidence of the sun on the window, the area of the window and a property of the window itself called the solar heat gain coefficient [4]. The important point of the solar heat gain coefficient of a window that determine the proportion of the light hitting the glass penetrate it.

The solar energy gains of a building; the power transmitted via windows (kW) If 2kW of sunlight is incident on house windows in winter then you can turn your heating down by 2kW. If 2kW of sunlight is incident on house windows in summer however, then that is 2kW of extra power that your air conditioning system needs to handle. The important question here: how you can best design a house to exploit these solar gains and so minimize the heating and cooling requirements of the house. This is called passive solar design. Like geothermal, it is a great way to heat buildings without emitting greenhouse gases [5].

There are two ways to control the sunlight entering the house

1-Designs of windows to overcome heating of day sun light

External sun shading is introduced within the design of the building facade so as to reduce heat transfer from the exteriors into the building. This is an efficient way to achieve a comfortable indoor temperature and make the building energy-efficient by reducing the overall air-conditioning costs.

Radiant heat from the sun passes through glass and is absorbed by building elements and furnishings, which then re-radiate it. Re-radiated heat has a different wavelength and cannot pass back out through the glass as easily. Sunlight admitted into a building impact on the building energy consumption in different ways in different seasons. In summer, excessive solar heat gain results in greater energy consumption due to the increased cooling load requirement. In winter, sunlight reaching the south-facing facade can provide passive solar heating. In all seasons of the year the sun improves daylight quality. Well-designed shading devices can significantly reduce building peak cooling load and corresponding energy consumption and enhance daylight utilization in buildings. Studies of the impact of shading on annual energy use have demonstrated that shading devices reduce the cooling demand in buildings while increasing the heating loads due to loss of beneficial solar gains. Shading devices can also avoid glare by reducing contrast ratios of building interior. Shading has been always recommended as a way for solar control and reduction of heat gain in buildings. It blocks direct solar radiation of the hot environments. There is both interior and exterior shade options which can be used to protect windows not otherwise shaded from the sun. In general it is best to block the sun before it reaches the window. The variety of shading strategies shown in this paper is effective at accomplishing that goal [6].

2-The material windows are made of

Glass is an extremely versatile material. It can be molded into a variety of shapes and sizes. It can be colored, glazed or left clear. There are actually a variety of techniques used to make different types of glass.

The application of phase change material (PCM) full of windows would definitely improve thermal insulation of the building and subsequently helps to decrease the building energy consumption. However, the studies on double-glazed windows and affect of integrating PCM with them were not enough addressed.

The measured transmittance of the window after combining Phase Change Material was more than 0.7 during daytime operating temperature and hence, it is obvious that it will permit good amount of light energy into the house.

The integration of PCM in double-glazed window helped to reduce the temperature fluctuation of the indoor space from 21 C to 11 C. Moreover, it reduced the indoor peak temperature by 9 C. The inner glass temperature was minimize by 8.5 C with the help of PCM and it reduced the energy consuming through the double-glazed window by 3.76% [7].

The inclusion of PCM and NDPCM in double-glazing windows helps in lowering the interior space's temperature fluctuation by 9.5 C and 5.5 C, respectively. The PCM and NDPCM (Nano-Disbanded Phase Changing Material) within the window panel conserved the energy of the building resulting by 3.79% and 4.61%, respectively. The NDPCM additionally conserved 0.85% more energy comparing to the PCM Window [8].

With the using of nano-silica disbanded crude wax (NDCW) affectedthe degree of isolation of heat inside the buildings. The peak value of the outside roofing temperature was lowered by 7.5 C and 10 C, respectively and the daytime mean temperature was lowered by 1.5 Cm and 2.5 C, respectively. Likewise, the roomside ceiling temperature was decreased by 12.5 C and 14 C during peak sunlight hours, and daytime mean temperature of the roomside ceiling was lessened by5.4 C and 6.5 C, respectively with the CW Roof and NDCW Roof. Further, the inclusion of crude wax lowered the inner room temperature by 10.5 C through peak sun shining hours and by 5 C when taking daytime mean value. The corresponding values for the NDCW were 12.5 C and 6 C, respectively [9].it may be used with the outer part of concrete or glass windows.

It is possible to achieve a significant reduction in building energy consumption via design of novel nanostructures for window applications. By a straight forward coating method, a thin film containing Fe_3O_4 nanoparticles can be applied on the glass substrate. Upon simulated solar light irradiation, the surface temperature can be raised resulting in reduced convective heat loss in winter. This is a mainly different approach in reducing window heat loss in winter via the photothermal effect of nanomaterials [10].

Through the study of different types of glass treated with nanotechnology, it was declared that whenever the Solar Heat Gain Coefficient (SHGC) was lower than 0.25. The glass treated with nanotechnology was 75% more energy than efficient because it reduces the thermal loads transferred from solar radiation within the space, and thus reduce the HVAC loads by more than 20%. Also, it was shown that whenever the light transmission was high, the glass was more energy-efficient as it provides daylight and by this way reduces the need for the artificial lighting which also reduces the energy [11-13].

Vanadium dioxide (VO_2) is an encouraging material for reducing the energy consumption, smart windows due to its reversible metal-to-insulator transition near room temperature and coming with big changes in its optical characteristics. The effects of intrinsic atomic defects, elemental doping, and lattice strain on VO_2 nanocrystals are examined. Nano- and micro scale morphology engineering approaches that aim to enhance the thermochromic performance and impart practical multi-functionalities are summarized [14].

Buildings consume huge amounts of energy in order to preserve thermal comfort for users. Through different buildings components, windows are considered as one of the most inefficient parts; so studies on energy-efficient windows have recently become critical due to the energy deficiency in the world. Thermochromic (TC) glazing is a new generation of energy-efficient smart glazing that passively changes its transmittance rate in response to temperature. Vanadium dioxide (VO_2) is the most widely used TC material in thermochromic windows. To increase the transparency of glazing, augment the thermochromic properties of VO_2, and set the transition temperature near the comfort zone, many dopants have been studied and many production methods have been studied. By using the sol-gel process, doped tungsten ions (W6+) on a vanadium dioxide film and also titanium dioxide (TiO_2) was added to the solution to produce a nanoparticle structure with both thermochromic and photocatalytic characteristics. To calculate the energy saving achieved by the produced TC glazing compared to standard products, a simple model of a room in a residential building was created with energy plus computer software. The simulation results declared that the fabricated TC glazing could bring about a considerable reduction in energy demand of buildings compared to current approaches [15].

Al-doped ZnO nano-pigments with an average particle size of 261 nm were prepared and dispersed in PMMA matrix for making multifunctional nanocomposite coatings. A single layer of AZO pigmented PMMA coatings having 269 mm thickness were obtained. This cover was found to display potential physico-chemical functionalities depending upon the number of coating layers. It was found that the coatings deliver perfect UV absorption in the maximum baleful area of UV radiation (290- 360 nm) and improved NIR reflectance at wavelengths of 810 and 1100 nm respectively. The Al-doping was preferable in enhancing the NIR reflectance. The UV active photo-degradation of MB dye assured the self-cleaning activity of the pigments in coatings [16]

The influence of annealing temperature on the structural, optical, and photoluminescent characteristics of aluminum doped ZnO(AZO) films prepared by sol-gel process have been studied for the temperature range of 200-700 °C. The crystalline quality was found to improve with the increase of the annealing temperature up to 600°C; this crystalline quality then begin to decrease for higher annealing temperatures. The optical band-gap was found to decrease with the increase of the annealing temperature. The normalized maximum value of the reflectance, and the PL intensity, were obtained for the annealing temperature of 600°C. Nevertheless the peaks of reflectance and PL in the near band region (NBE) were found to increase with the raising of the annealing temperature. A good connection between the IG/INBE ratio and the reflectance value at λ = 1000 nm and the annealing temperature was found. This improvement may be due to the variation of the grains (grain boundaries) of the nano-structured AZO films with annealing temperature [17].

Undoped zinc oxide (ZnO) has received much attention because of its potential uses in many applications such as antireflection coating in solar cells, UV light emitting diodes, laser diodes, varistors, and transparent conducting films [18-23]. ZnO films indicates two emission peaks in the UV and visible regions. The visible (blue-green) emission may be related to some intrinsic defects such as zinc vacancies, interstitial oxygen (Oi-), and oxide anti-site defects (OZn) made local deep levels in the band gap of ZnO [24,25]. Doped ZnO films indicate stable electrical and optical properties. Al-doped ZnO films have good electrical conductivity and optical transmittance in the visible and near-infrared regions [26,27].

Trivalent lanthanide (Ln^{3+}) doped luminescent nanocrystals are promising for applications ranging from biosensor, lasing, super resolution nanoscopy, information security and so on. Although the utility prospect is of great attractions, the light absorption of these lanthanide doped nanocrystals is inherently weak due to the electric dipole-forbidden 4f 4f transitions. Even worse, the quantum yields of upconverison nanocrystals are very low, which will unavoidably hinder their further applications. In a typical lanthanide luminescent nanosystem, both sensitizers as light absorption centers and activators as light emitting centers are necessary and important for desired luminescence properties. Among various sensitization systems, only Yb^{3+} and Nd^{3+} are considered as the most efficient sensitizers. Thus, the corresponding excitation wavelengths are strictly limited around 980 and 808 nm. [28].These dopant doesn't use in shielding solar energy but it may be use in the future.

Er3+-Tm3+ co-doped novel bismuthate glasses with different [Tm]/[Er] ratios have been prepared by melt-quenching method. A fairly flat and broad emission covering the wavelength range of 1300-1650 nm corresponding to the 3H4 →3F4 transition of Tm3+ and 4I13/2 →4I15/2 transition of Er3+ can be observed with the excitation of 800 nm laser. A full width at half maximum (FWHM) of ~160 nm is obtained by codoping the glass with 1.0 wt% of Tm_2O_3 and 0.3 wt% of Er_2O_3. The energy transfer processes between Tm^{3+} and Er^{3+} in BGN glasses are analyzed in detail. The temperature dependence of the broadband emission spectra in Er^{3+}-Tm^{3+} co-doped BGN glass is also studied, which is helpful to understand the energy transfer processes. Er^{3+}-Tm^{3+} co-doped BGN glasses can be promising materials for broadband light sources and broadband amplifiers for WDM transmission systems [29].

Co-doped ZnO particles have been fabricated using the sol-gel method and their structural, optical, surface and magnetic properties as a function of doping concentrations were studied. The optical band gap was found to decrease from 3.99 to 3.2 with increasing doping level, indicates red shift. These high band gaps may be used as absorbing layer in solar cells. The specific saturation magnetization values were found to decrease and coercivity increased with increasing Co concentrations arising from Co ions. Porous structure of Co doped ZnO is desirable for the electrochemical properties of electro-chromic materials as well as catalysts. It is concluded that Co doped ZnO nanoparticles with low dimensions and high band gap are synthesized first time. Owing to their characteristic they find use in dilute magnetic semiconductor (DMS) nano-devices [30].

The addition of nanoparticles reduces the transmission of paraffin. At visible wavelengths, the spectral transmittance of nanofluids increases with increasing temperature and decreasing nanoparticles concentration. Moreover, in the same wavelength range, CuO/ paraffin exhibits a stable attenuation of light intensity compared with ZnO/paraffin.

Nanoparticles improve the light absorption efficiency, which allows achieving higher photothermal conversion efficiency. The nanoparticle concentration range of $5 \times 10^{-4} \sim 1.5\times10^{-3}$ vol% can meet the optimal performance of light transmission and thermal properties at the same time [31].

II. CONCLUSION

From the previous survey of the most researches that have been studied in recent years for the use of nanoparticles to change the properties of glass used in either thermal or light insulation or any electronic application that affects the properties of glass, and through this combination, one can reach the best dopants that can be used in the future. According to this scan nano phase can be present in the structure of glass through different methods like annealing temperature, method of preparation and doping percentage composition.

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