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FUTURE OF INTELLIGENT WINDOWS

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ABSTRACT

The temperature inside a building heavily depends on the incident sun light through the window. A solution to control the building temperature is to dynamically control the transparency of the windows in its window. Smart glass, E-Glass, or switchable glass, also called smart windows or switchable application to windows or skylights, refers to electrically switchable glass or glazing which changes light transmission properties when voltage is applied.

"Smart" window technology is the most promising option and a lot of research is being done in this field that can both save and generate energy, and may ultimately reduce heating and cooling costs for buildings. While allowing us to feel close to the outside world, windows cause heat to escape from buildings in winter and let the Sun's unwanted rays enter in summer. This has sparked a quest for "smart" windows that can adapt to weather conditions outside. In this paper we discussed about how smart windows are limited to regulating light and heat from the sun, allowing a lot of potential energy to escape."The main innovation of this work is that it developed a concept smart window device for simultaneous generation and saving of energy.

KEYWORDS: Intelligent, Windows

INTRODUCTION

The topic of **smart windows** in a further sense includes LED (Light Emitting Diodes) Embedded Films which may be switched on at reduced light intensity. The process of laminating these LED embedded films between glass will allow the production of Transparent LED embedded glasses. As most glass companies are not skilled in mounting LEDs onto metallized glass the LEDs are located on a separate transparent conductive polymeric interlayer that may be laminated by any glass lamination unit

Engineers have long battled to incorporate energy-generating solar cells into window panes without affecting their transparency. They discovered that a material called vanadium oxide (VO2) can be used as a transparent coating to regulate infrared radiation from the Sun.VO2 changes its properties based on temperature. Below a certain level it is insulating and lets through infrared light, while at another temperature it becomes reflective. A window in which VO2 was used could regulate the amount of Sun energy entering a building, but also scatter light to solar cells the team had placed around their glass panels, where it was used to generate energy with which to light a lamp, for example."This smart window combines energy-saving and generation in one device, and offers potential to intelligently regulate and utilise solar radiation in an efficient manner," Researchers are developing new smart windows that could allow people to control the heat and sunlight entering their houses. New materials have been engineered that let windows to allow light without transferring heat and, conversely, to block light while allowing heat transmission, researchers said.

Using a small jolt of electricity, a nanocrystal material could be switched back and forth, enabling independent control of light and energy. The team now has engineered two new advancements in electrochromic materials - a highly selective cool mode and a warm mode - not thought possible several years ago. The cool mode material is a major step towards a commercialised product because it enables control of 90 per cent of NIR and 80 per cent of the visible light from the Sun and takes only minutes to switch between modes.This could help reduce energy costs for cooling buildings and homes during the summer.

The concept includes a simple coating that creates a new warm mode, in which visible light can be blocked, while near-infrared light can enter. This setting could be useful on a sunny winter day, when one would want infrared radiation to pass into a building for warmth, but the glare from sunlight to be reduced.

DESCRIPTION

Qualities of PDLC Smart Window

- **Technology**

Smart Glass Film is based on digital shading technology that allows the color of the film to go from non-transparent to transparent when you apply a current through it. Smart Glass Film will will give you the option for privacy o n demand by adjusting the amount of light traveling through your window.(PDLC Film) Material.

- **High Privacy**

The biggest function of Smart Glass Film is privacy protection function, can control the glass transparent and non-transparent state anytime. And When Smart Glass Film is in the nontransparent state, it can be as a projector screen which will be handy in your office.

- **High Security**

Smart Glass Film has all the advantages of safety glass. Smart Glass Film is not just for privacy or sunblock, but it also absorbs UV rays and reflects infrared to keep your room temperature lower and in turn saving you energy.

- **Environmental Protection Feature**

Blocks more than 99% UV rays ,avoiding fading in the room.

- **Sound Proof**

With excellent damping action, the smart glass is easy to block the noise.

- **Projection**

Smart glass is a good projection screen. When it is under suit light,the perfect projection appears.

Recent advancements in modified porous nano-crystalline films have enabled the creation of electrochromic display. The single substrate display structure consists of several stacked porous layers printed on top of each other on a substrate modified with a transparent conductor. Each printed layer has a specific set of functions. A working electrode consists of a positive porous semiconductor (say Titanium Dioxide, TiO2) with adsorbed chromogens (different chromogens for different colors). These chromogens change color by reduction or oxidation. A passivator is used as the negative of the image to improve electrical performance. The insulator layer serves the purpose of increasing the contrast ratio and separating the working electrode electrically from the counter electrode. The counter electrode provides a high capacitance to counterbalances the charge inserted/extracted on the SEG electrode (and maintain overall device charge neutrality). Carbon is an example of charge reservoir film. A conducting carbon layer is typically used as the conductive back contact for the counter electrode. In the last printing step, the porous monolith structure is overprinted with a liquid or polymer-gel electrolyte, dried, and then may be incorporated into various encapsulation or enclosures, depending on the application requirements. Displays are very thin, typically 30 micrometer, or about 1/3 of a human hair. The device can be switched on by applying an electrical potential to the transparent conducting substrate relative to the conductive carbon layer. This causes a reduction of viologen molecules (coloration) to occur inside the working electrode. By reversing the applied potential or providing a discharge path, the device bleaches. A unique feature of the electrochromic monolith is the relatively low voltage (around 1 Volt) needed to color or bleach the viologens. This can be explained by the small over-potentials needed to drive the electrochemical reduction of the surface adsorbed viologens/chromogens.

APPLICATIONS

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- **Electrochromic windows** darken when voltage is added and are transparent when voltage is taken away. Like suspended particle devices, electrochromic windows can be adjusted to allow varying levels of visibility. They are not an all-or-nothing technology like liquid crystals.

Electrochromic windows center around special materials that have **electrochromic** properties. "Electrochromic" describes materials that can change color when energized by an electrical current. Essentially, electricity kicks off a chemical reaction in this sort of material. This reaction (like any chemical reaction) changes the properties of the material. In this case, the reaction changes the way the material reflects and absorbs light. In some electrochromic materials, the change is between different colors. In electrochromic windows, the material changes between colored (reflecting light of some color) and transparent (not reflecting any light).

Electro Chromic Smart Glass

Smart glass, or electro chromic glass, uses a tiny burst of electricity to charge ions on a window layer and change the amount of light it reflects. While low-emittance windows that block some of the sun's radiation already exist, smart glass gives you the ability to choose how much light you want to block. Smart glass developers expect a 25 percent reduction in HVAC costs thanks to the dynamic windows.

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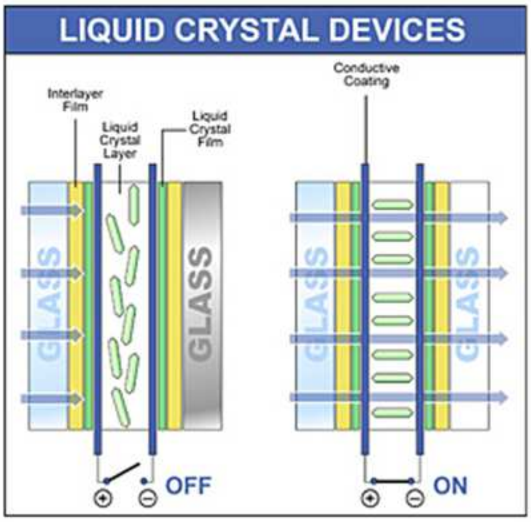

Figure 1

Ordinary windows are made from a single vertical pane of glass and double-glazed windows have two glass panes separated by an air gap to improve heat insulation and soundproofing (to keep the heat and noise on one side or the other). More sophisticated windows (using low-e heat-reflective glass) are coated with a thin layer of metallic chemicals so they keep your home warm in winter and cool in summer. Electrochromic windows work a little bit like this, only the metal-oxide coatings they use are much more sophisticated and deposited by processes similar to those used in the manufacture of integrated circuits (silicon computer chips).

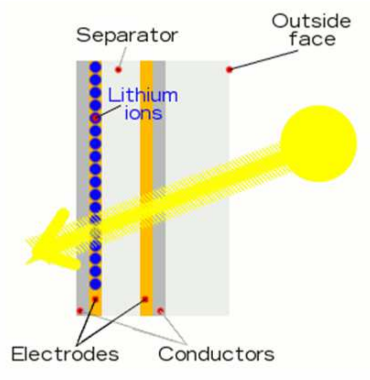

Figure 2

Although we often talk about "electrochromic glass," a window like this can be made of either glass or plastic (technically called the "substrate," or base material) coated with multiple thin layers by a process known as sputtering (a precise way of adding thin films of one material onto another). On its inside surface (facing into your home), the window has a double-sandwich of five ultra-thin layers: a separator in the middle, two electrodes (thin electrical contacts) on either side of the separator, and then two transparent electrical contact layers on either side of the electrodes. The basic working principle involves lithium ions (positively charged lithium atoms—with missing electrons) that migrate back and forth between the two electrodes through the separator. Normally, when the window is clear, the lithium ions reside in the innermost electrode (that's on the left in the diagram you can see here), which is made of something like lithium cobalt oxide ($LiCoO_2$). When a small voltage is applied to the electrodes, the ions migrate through the separator to the outermost electrode (the one on the right in this diagram). When they "soak" into that layer (which is made of something like polycrystalline tungsten oxide, WO_3), they make it reflect light, effectively turning it opaque. They remain there all by themselves until the voltage is reversed, causing them to move back so the window turns transparent once again. No power is needed to maintain electrochromic windows in their clear or dark state—only to change them from one state to the other.

Polymer Dispersed Liquid Crystal Devices

In polymer dispersed liquid crystal devices (PDLCs), liquid crystals are dissolved or dispersed into a liquid polymer followed by solidification or curing of the polymer. During the change of the polymer from a liquid to solid, the liquid crystals become incompatible with the solid polymer and form droplets throughout the solid polymer. The curing conditions affect the size of the droplets that in turn affect the final operating properties of the "smart window". Typically, the liquid mix of polymer and liquid crystals is placed between two layers of glass or plastic that include a thin layer of a transparent, conductive material followed by curing of the polymer, thereby forming the basic sandwich structure of the smart window. This structure is in effect a capacitor.

Electrodes from a power supply are attached to the transparent electrodes. With no applied voltage, the liquid crystals are randomly arranged in the droplets, resulting in scattering of light as it passes through the smart window assembly. This results in the translucent, "milky white" appearance. When a voltage is applied to the electrodes, the electric field formed between the two transparent electrodes on the glass causes the liquid crystals to align, allowing light to pass through the droplets with very little scattering and resulting in a transparent state. The degree of transparency can be controlled by the applied voltage. This is possible because at lower voltages, only a few of the liquid crystals align completely in the electric field, so only a small portion of the light passes through while most of the light is scattered. As the voltage is increased, fewer liquid crystals remain out of alignment, resulting in less light being scattered. It is also possible to control the amount of light and heat passing through, when tints and special inner layers are used. It is also possible to create fire-rated and anti X-Ray versions for use in special applications. Most of the devices offered today operate in on or off states only, even though the technology to provide for variable levels of transparency is easily applied. This technology has been used in interior and exterior settings for privacy control (for example conference rooms, intensive-care areas, bathroom/shower doors) and as a temporary projection screen. It is commercially available in rolls as adhesive backed Smart film that can be applied to existing windows and trimmed to size in the field.

Micro-Blinds

Micro-blinds—currently under development at the National Research Council (Canada)control the amount of light passing through in response to applied voltage. Micro-blinds are composed of rolled thin metal blinds on glass. They are very small and thus practically invisible to the eye. The metal layer is deposited by magnetron sputtering and patterned by laser or lithography process. The glass substrate includes a thin layer of a transparent conductive oxide (TCO) layer. A thin insulator is deposited between the rolled metal layer and the TCO layer for electrical disconnection. With no applied voltage, the micro-blinds are rolled and let light pass through. When there is a potential difference between the rolled metal layer and the transparent conductive layer, the electric field formed between the two electrodes causes the rolled micro-blinds to stretch out and thus block light. The micro-blinds have several advantages, including switching speed (milliseconds), UV durability, customized appearance and transmission. Theoretically, the blinds are simple and cost-effective to fabricate.

Nanocrystal

A thin coating of nanocrystals embedded in glass can provide selective control over both visible light and heat-producing near-infrared (NIR) light independently climates. The technology employs a small jolt of electricity to switch the material between NIR-transmitting and NIR-blocking states. Nanocrystals of indium tin oxide embedded in a glassy matrix of niobium oxide form a composite material. The voltage ranges over 2.5 volts. The same window can also be switched to a dark mode, blocking both light and heat, or to a bright, fully transparent mode. The effect relies on a synergistic interaction in the region where glassy matrix meets nanocrystal that increases the electrochromic effect. The atoms connect across the nanocrystal-glass interface, causing a structural rearrangement in the glass matrix.The interaction creates space inside the glass, allowing charge to move more readily

Polymer Solar Cells

Polymer solar cells are basically made by imprinting inorganic semiconducting material over the flexible substrate. The substrate chosen is generally a polymeric substance which is made conductive by applying thin films of conducting material. These polymers are coated with transparent conducting oxides which act as cathode for the cells. This is coated with zinc oxide/titanium dioxide conducting substrate which increase the life of ITO that otherwise is degraded. These solar cells consist of a layer of nanoparticles only few nanometers thick, dispersed over a polymer. To further increase the efficiency of the cell an active layer is coated that forms an electron donor acceptor junction. Materials that form electron donor are generally conjugating polymers which possess delocalized π electron of carbon p-hybridized orbital. The electron acceptor is made of fullerenes based materials. On these cells silver/aluminum paste is applied to form anode. These active layers can be printed in ambient conditions using various thin film coatings like screen printing, inkjet printing, spin coating etc. Because of the flexibility in these cells they can be easily installed and even can directly print on surfaces like roofs for supplying electricity to houses. These cells are very easy to use as shown in figure 3. The fabricated cell is put on water bath and then directly be printed on desired section for use.

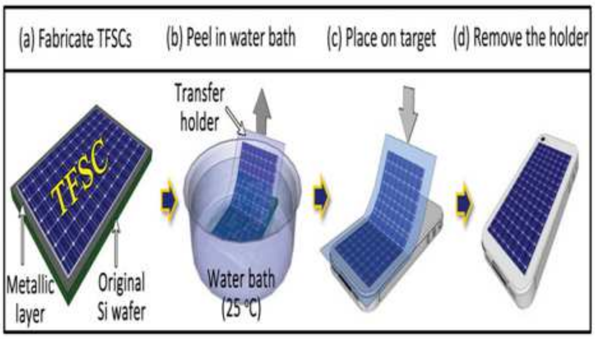

Figure 3: Schematic Diagram of Peel and Stick Flexible Solar Cell [3]

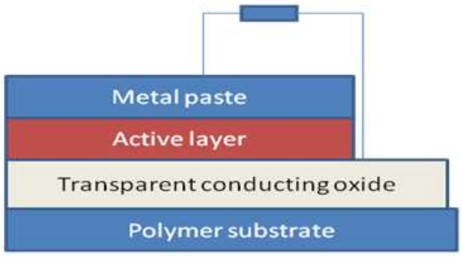

Figure 4: Schematic of Flexible Solar Cell

The layers of transparent conducting oxides can easily be screen printed on glass windows and can be used for giving power to house. These solar cells can also be used for powering the small electronic gadgets also like mobile phones, calculators so they can be charged by sunlight itself. In these cells panel uses organic molecules made to absorb invisible wavelengths of light, such as ultraviolet and near infrared light. The material moves this unseen light to the edges of the panel, where strips of photovoltaic solar cells pick it up and convert it to electricity. The main advantage of using this technology is its low cost because it does not require high cost and high temperature processing equipments like vacuum chambers etc.

Although this thin film technology is capable to supply electricity to low power devices. It can provide electricity for rural areas where grid electricity is not available. It can also be used in sub urban areas to reduce the loads on grid electricity supply. The use of this technology also reduces dependence on fossil fuels which would help to reduce pollution. Thus plastic solar cells help the process to be energy efficient and largely contribute in making the concept of green building live.

CONCLUSIONS

Currently smart windows are installed as self-contained units: you fit an entire window unit with its specially coated glass at great expense. In the future, scientists working on electrochromic technology hope to develop very thin coatings that could be retro-fitted to existing windows, greatly reducing the cost of the process. (Picture a reel of self-adhesive plastic that you stick on your existing windows as a weekend DIY project.)

Another possibility might be to combine electrochromic windows and solar cells so that instead of uselessly reflecting away sunlight, darkened smart windows could soak up that energy and store it for later. It's easy to imagine windows that capture some of the solar energy falling on them during the day and store it in batteries that can power lights inside your home at night, though, of course, a window can't be 100 percent transparent and working as a 100 percent efficient solar panel at the same time. The incoming energy is either transmitted through the glass or absorbed and stored, but not both. A window that doubled as a solar cell would likely involve compromise from both sides: it'd be a relatively dark window even when clear and much less efficient at capturing energy than a really good solar cell.

One thing we can be sure of is seeing much more of electrochromic technology in future!

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