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MULTIPLE APPLICATIONS OF ELECTROCHROMIC MATERIALS IN THE AUTOMOTIVE INDUSTRY[1]

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Abstract

Electrochromism is the phenomenon of reversible and steady colour change of materials with the action of applied electric field. Electrochromic materials change their optical properties, such as: reflectivity, transmissivity, absorptivity when a small voltage is applied. The optical device which incorporates electrochromic materials is called an electrochromic device. The electrochromic materials, incorporated in electrochromic devices can be used in various fields, including automotive auto-dimming rearview mirror, electrochromic smart glass, electrochromic display, sunglass and goggles, military camouflage gear, sensor, optical shutter or optical modulator.

Keywords–electrochromic materials; rearview mirror; automotive industry

INTRODUCTION

Electrochromism is a colouring phenomenon observed in some materials when they are placed in a presence of an electric field. Such materials exhibiting reversible colour changes are known as an electrochromic (EC) materials. The electrical field dependent transition phenomenon from an uncoloured state to a coloured state is called optical switching.When no electrical field is placed on the EC material, it is uncoloured and transparent and thus one can look through it. On the other hand, when it is subjected to an electric current, it colours thereby reducing the amount of light transmitted through it or reflected by it. The reduction of light transmission may be partial or total thereby either reducing the amount of light which

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passes through it or eliminating it altogether.Electrochromism in W oxide films was first discovered by Deb in 1969 [1].

An electrochromic device is essentially a rechargeable battery with the electrochromic electrode separated by a solid, gel, or liquid electrolyte from a charge-balancing counter electrode. There are many possible electrochromic device construction. The standard configuration of an electrochromic device aimed at practical utilization of electrochromism is: glass/ transparent conductor/ ion conducting layer (electrolyte)/ electrochromic layer/ transparent conductor (ion storage layer)/ glass. All layers are several micrometers thin. When a voltage is applied between the conductors ions are moved uniformly into and out of the electrochromic film. The charge balancing counterflow of electrons through the external circuit then leads to variation of the electron density in the EC material and thereby a modulation of their optical properties, which remain stable for a long period of time [1].The colour of electrochromic materials in their coloured and bleached state depends on the material used and the voltage applied between the electrodes. The applied voltage is small, only a few volts. Commercial devices require EC materials with a high contrast ratio, high coloration efficiency, long cycle life, high write-erase efficiency and fast response time.

Since Deb put forward the concept of electrochromism for the first time, EC materials and devices have been a hot area of research globally. EC materials are currently attracting much interest in academia and industry for both their fascinating fundamental spectroelectrochemical properties and their commercial applications. A large number of transition metal oxides such as WO_3 , TiO_2 , NiO_x , V_2O_5, Cu_2O etc., have been investigated as electrochromic materials [1-4]. Today a large number of electrochromic materials are available from all branches of synthetic chemistry, too.

APPLICATION AREA FOR ELECTROCHROMIC DEVICES IN AUTOMOTIVE INDUSTRY

As the ionic transport, and thus the change in optical properties of the electrochromic material is reversible. That is why electrochromic coating, when incorporated in electrochromic devices offers dynamic reflection/ transmission modulation of radiant energy. There are many uses of materials whose optical properties can be varied reversibly and persistently by a low voltage signal. As a result, electrochromic devices have fascinating possibilities to be used in the automotive industry, too.

Electrochromic glass represents an important step forwards in the use of glass, both in the field of building construction and in the car industry, as

glass of this kind can modify its transparency and reflectivity as required, when an electric field is applied for a specified time.

Electrochromic (EC) auto-dimming mirrors

Headlight glare in the mirrors from trailing vehicles can make it very difficult to see the road in front. This is particularly dangerous on dark rural highways with cross-traffic. Drivers who have driven at night on dark roads know that the light from incoming traffic is not the biggest problem, but the seconds after that light has disappeared, leaving utter darkness in its wake. Even after the glare is removed, an after-image remains on the eye's retina that creates a blind spot for the driver. This phenomenon, known as the Troxler effect, postpones driver reaction time by up to 1.4 seconds. At 100 km/h, a car will travel about 38 m in this amount of time. Human factors studies relate driver discomfort to incident glare and the results are incorporated into a fully automatic mirror whose reflectivity varies dynamically to suit changing driving conditions [5-7].

Fig. 1. Regular and auto-dimming rearview mirror

Auto dimming rear-view mirrors, both the interior mirror at the top of the windshield and the exterior side mirrors, are intended to counteract the Troxler fading effect andincrease driving safety by eliminating glare that can impair vision. Electrochromic mirrors have variable reflectivity and this offers an opportunity to select a reflectance level that avoids glare, but that maintains rear vision. In automatic mode, the electrochromic mirror responds appropriately to all driving situations, and mirror operation is transparent to the driver with smooth response and no unexpected change.

A dimming mirror is just a piece of glass, but with some interesting characteristic. The glass' main feature is the ability to turn from a clear (uncoloured) to a tinted, colored state, when subjected to light (Fig. 1). In order for the dimming mirror to be effective, something must tell it when it’s time to act. Dimming mirrors used in the automotive industry are fitted with sensors to detect the intensity of the light. Usually, there are two sensors, one pointed to the front and the other to the rear. The interior mirror's sensors and electronics control the dimming of both interior and

exterior mirrors. The sensors, when active, are constantly looking for low ambient light. Poor lighting tells the sensors that the driver is driving at night and they begin looking for a glare source which may impair driver's vision. When they detect a change in light intensity, they trigger an electrical charge to be applied to the glass through a low-voltage power supply. The electricity travels through an electrochromic gel placed between two pieces of glass during manufacturing, which have been treated with an electrically conductive coating. As a result, the mirror darkens automatically and proportionally to the light detected by the sensors (proportionally to how bright the glare is). When the glare is no longer detected, they revert to their idle (clear, uncoloured) status.

Many of the components of the automatic-dimming mirrors (sensors, circuit boards, micro-controllers, etc.) can be shared with other advanced features to save cost and space, while reducing part counts and overall vehicle complexity. They're also easy to install, allowing vehicle manufacturers to bring the new features to the market quickly and efficiently across different vehicle platforms. Automatic-dimming mirrors are easily accessible, simplifying diagnostics and service. If necessary, they can easily be replaced.

U.S. Gentex is the first company that materializes automotive auto-dimming rearview mirrors, producing 29 million sets in 2014, about 90% of the global market share. Gentex introduced the first dimming rear view mirror in 1982, but it was only in 1987 when the first electrochromic-based dimming technology came to be. At the time, such mirrors were available only for interior use, the exterior versions of the technology being developed only in 1991 [5-7].

Electrochromic (EC) windows -are architectural or automotive windows with EC coatings that allow them to darken and lighten upon the application of a very small electric voltage. Key factors promoting the use of smart automotive glass include enhanced energy efficiency, safety, comfort and style. These factors are not new to the auto industry but ongoing technology improvements allow smart glass firms to better create value with their products.They have variable transmittance so that a desired amount of visible light and/or solar energy is induced. Such windows can lead to energy efficiency as well as comfortable indoor climate. EC windows are an advanced technology which can be used in the automotive industry (Fig. 2).Maintenance of color intensity requires a small current, negligible in a car.

In addition, this technology is also used in motorcycle visors, using an EC foil which consists of thin oxide layers laminated between two flexible polymer sheets. The foils are first coated with transparent electrically conducting layers and then with active electrochromic layers. The lamination

process uses a special ion-conducting electrolyte that makes it possible to charge and discharge the electrochromic layers, thus getting them to absorb or not absorb visible light. This application is said to be able to greatly reduce the amount of accidents caused by changing light conditions.

Fig. 2. Smart EC glass in automobile

Information display – This device of small or large size embodies an electrochromic film in front of a diffusely scattering pigmented surface. It is possible to achieve excellent viewing properties with better contrast – particularly at off-normal angels than in the conventional liquid crystal based displays, without constantly drawing power [1]. Today such displays are available at some railway and bus stations.

Adaptive camouflage - carmeleon - This system is aimed to change the color of car bodies to fulfill two needs: safety and aesthetic pleasure. The system consists of an insulating substrate/ conducting layer/ electrochromic layer/ electrolyte layer/ conducting layer/ insulating substrate. When a voltage is applied to the device, an electrochemical reaction takes place and the electrochromic layer changes its colour. As a safety device, the system allows broken-down vehicles to change their colour into a certain specific colour, which must be accepted and approved by authorities, which will inform others of its state and thus, approach the broken-down vehicles with caution and reduced speed. The problem of low visibility of vehicles due to certain environmental conditions such as heavy rain and fog can be solved by changing their colour and thus increasing their luminance and making them more visible to other road users. By allowing car owners to change the colour of their cars by pressing a button, they beautify their cars with greater efficiency and at a minimum time, thus saving time and efforts.

CONCLUSION

Electrochromism is a reversible and visible change in the transmittance and/or reflectance of a material as a result of electrochemical oxidation or reduction. The field of electrochromism is rapidly expanding in novel systems of applications.

The most widespread commercially available device at present is the car rear-view mirror. Research shows that during nighttime driving, headlight glare from the vehicles traveling behind can be blinding. Electrochromic auto-dimming mirrors make nighttime driving safer by detecting glare and automatically dimming to protect driver vision.

Electrochromic glass represents an important step forwards in the use of glass, both in the field of building construction and in the car industry, as glass of this kind can modify its transparency as required, when an electric field is applied for a specified time.

Electrochromic displays have good visibility in a variety of conditions and viewing angles, without constantly drawing power.

Moreover, maybe adaptive camouflage of vehicles will be the modern way to change the colors of vehicle’s bodies in the years to come, fulfilling two needs: a safety device and aesthetic pleasure.

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