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Durability of switching behaviour after outdoor exposure for a suspended particle device switchable glazing

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ABSTRACT

Adaptive suspended particle device (SPD) switchable glazing is promising for low energy building application. SPD glazing allows light passes through it in the presence of applied voltage and block light in the absence of power supply. In this work SPD glazing performance after 3 years of outdoor exposure was evaluated. It was found that contrast ratio of SPD glazing before and after exposures changed from 1:11 to 1:10. SPD glazing surface temperature for any transparency level varies between 13 and 40 °C under indoor and outdoor thermal exposure. SPD glazing's surface temperature variation occurs due to the incident radiation level, not for the transmission level of glazing. Voltage and power requirement of SPD glazing did not vary at elevated glazing surface temperature.

1. Introduction

Admitted solar radiation through a glazing of a building enhances the temperature swing, which introduce thermal discomfort in summer and thermal comfort in winter. Thus, solar gain has positive effect in winter and reduces heating energy demand; on the other hand, it induces cooling load demand in summer. Glazing of a building also plays an important role for visual performance. Widely available glazings are double pane and single pane. Constant transparency single and double-glazing does not perform satisfactory to reduce building energy demand and thermal comfort [1] as admitted solar radiation is diurnal in nature. Due to sun position variation throughout the year, a vertical plane glazing often experiences variable transmittance of solar spectrum.

Thus glazing having more than one transmittance is beneficial for building application. Switchable glazings offer more than one optical transmittance enabling the glazing to adapt to different solar heat gain conditions [2–9].

Switchable adaptive glazings include electrochromic (EC) [10–13], liquid crystal (LC) [14,15], suspended particle device (SPD) [16,17], thermochromic [18,19], gasochromic [20,21], thermotropic [22,23], phase change material (PCM) [24–27] types. Thermochromic, thermotropic, gasochromic and PCM are non-electrically actuated glazing whilst EC, LC and SPD are electrically actuated glazing. These glazing act differently in their transparent and opaque state to control the transmitted solar radiation. Thermochromic material at higher temperature reflects infra-red (IR) solar radiation and absorbs ultraviolet (UV) during its transition from transparent to opaque state [18,19]. Thermotropic material at low temperature becomes "transparent" and above switching temperature, both transmitted and reflected lights are scattered and makes it "opaque" [22,23]. Solid PCM material inside PCM glazing, absorbs IR, become liquid, and passes visible solar radiation [27]. Electrically actuated glazing in contrast with non-electrically actuated can be controlled based on occupant criteria.

Electrically actuated EC glazing absorbs IR spectrum of solar radiation [28]. In addition, at higher glazing surface temperature this glazing requires less power to switch [29,30]. LC glazing at opaque state scatters the light, become haze, and provides no control of NIR [31]. SPD glazing can control only the visible solar spectrum and transmit IR spectrum [32].

EC glazing is the most investigated glazing device among all other electrically actuated glazing. However EC glazing can suffer from (i) its low durability (sensitive to UV) [33], (ii) high increased surface temperature, (iii) slow colouration process; and (iv) non uniform colouration process for large-scale glazing application [34–37]. Thus for building application SPD glazing can be considered potential over EC and LC glazing.

Suspended particle device (SPD) technology was patented by Dr Edwin Land in 1934 [38,39]. Dihydrocinchonidine bisulfite polyiodide or herapathite particles can be needle-shaped, rod-shaped, or lath-shaped. In the absence of an applied electrical field, the particles move randomly in a liquid suspension due to Brownian movement. In this state, light passing into the cell is rejected, transmitted or absorbed depending upon the cell structure, the nature of particles, concentra-

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tion of the particles and the energy content of the light [40]. The presence of an electric field causes the particles become aligned so that most of the light can pass through the cell [41]. For glazing applications, plastic films rather than a liquid suspension are used. Plastic film avoids a liquid bulging effect due to hydrostatic pressure and leaking from the device. In a plastic film, the fewer number of particles do not noticeably agglomerate when the film is repeatedly activated with a voltage [42,43]. In current practical device, rotating particles are trapped inside a dual layer of plastic film as shown in Fig. 1. Presence of conducting layer makes it to behave like parallel plate capacitor.

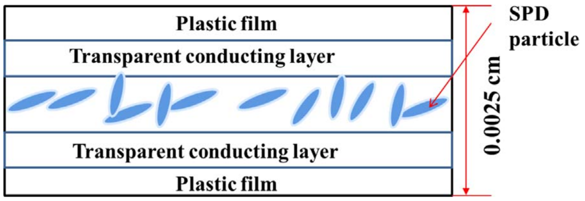

Fig. 1. Cross section of a SPD film manufactured by Research Frontiers.

The thermal [44], daylighting [45] and electrical [46] performance of a commercial SPD glazing as shown in Fig. 2 have been characterised using outdoor test cell. This 0.034 m^2 SPD glazing offered a contrast ratio (ratio of minimum and maximum transmittance) of 1:11 for opaque and transparent state [44]. SPD glazing offers switchable single glazing behaviour as it possess high over all heat transfer 5.9 W/m^2 K [44] while solar heat gain coefficient change from 0.05 to 0.38 [47]. A low heat loss SPD glazing was also examined using SPD and vacuum glazing together [48]. This system offered 72% improvement of overall

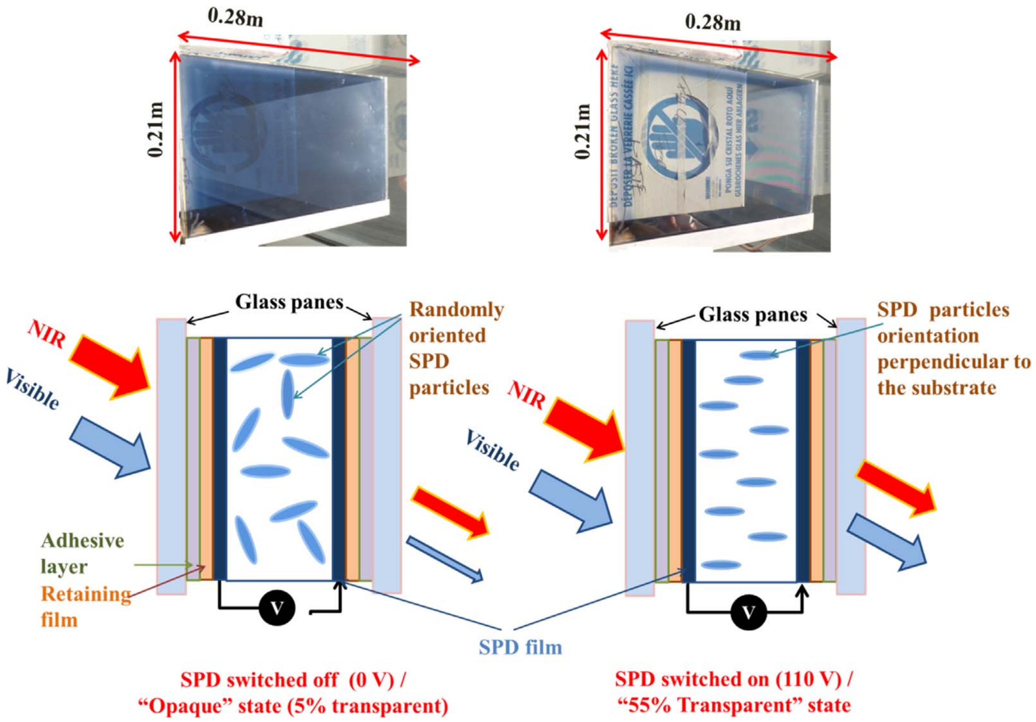

Fig. 2. Photographic view and details of SPD glazing in opaque and transparent state.

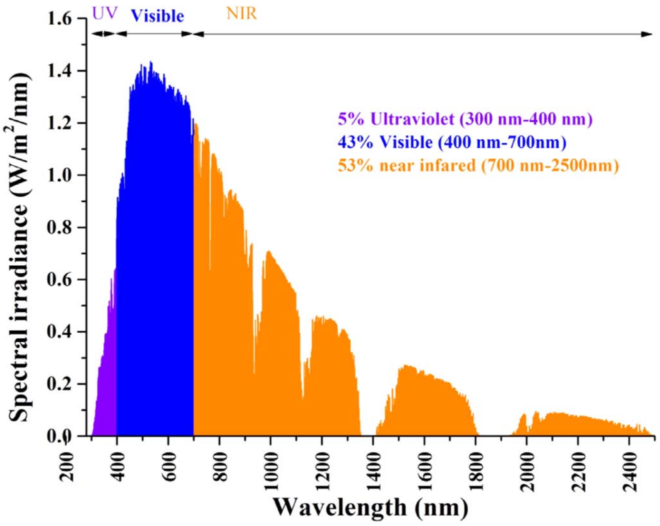

Fig. 3. Solar energy distribution.