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Experimentations on luminescent glazing for solar electricity generation in buildings

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ABSTRACT

The aim of this study is developing an efficient and practical approach for utilization in buildings of windows and façades for solar energy conversion without impeding vision through glazing. For that purpose, the glazing is processed with a luminescent coating allowing recovering of the high energy photons from the Ultra Violet (UV) spectrum. Indeed, the recovered UV photons are spectrally shifted into the visible spectrum by the luminescent coating and are directed to edges of glazing. By embedding photovoltaic cells of monocrystalline silicon types into the frame of window prototype, it is verified that solar energy conversion is effective from glazing edges. The electricity generated from the edges of the luminescent windows is valuated. The photocurrent and power are increased by adding a tinting film on the backside of luminescent glazing. Experimental tests and analysis of a prototype in operation have been practiced.

1. Introduction

The Photovoltaic (PV) panels are more and more used for the production of green electrical energy in a centralized approach as like in large power plants but also by a distributed approach at the level of homes building or other infrastructure in urban or rural areas [1–3]. The use of these solar panels in the case of the distributed approach requires their installation on roofs or facades of buildings according to known technology of BIPV (Building Integrated Photovoltaic) or BAPV (Building Added Photovoltaic) [4–6]. The BIPV panels are quite expensive panels and do not allow a clear view of the surrounding landscape through the glass as either in the window or in opening roof (Sky Light) [7–9]. Furthermore, the orientation and tilt are critical to the performance index of the system made with BIPV and BAPV or Sky Light modules [10–12].

In this work, an interesting approach is demonstrated according to the technology of Luminescent Solar Concentrator (LSC) that allows producing energy from luminescent glass for that purpose. A simplified process of dip coating is investigated [13–15], in order to facilitate the integration of the LSC technology in the manufacturing process of glazing and windows.

The LSC device is based on the combining of luminescent coatings on glass and the spectrum down shift phenomenon that will transform the high energy photons into lower energy photons in the visible wavelengths that get out from the edges of glazing [16–19]; where solar cells will be positioned to make the photovoltaic conversion. This gives transparent windows that allow visual comfort without the drawback of obstructing the passage of light from PV cells comparatively

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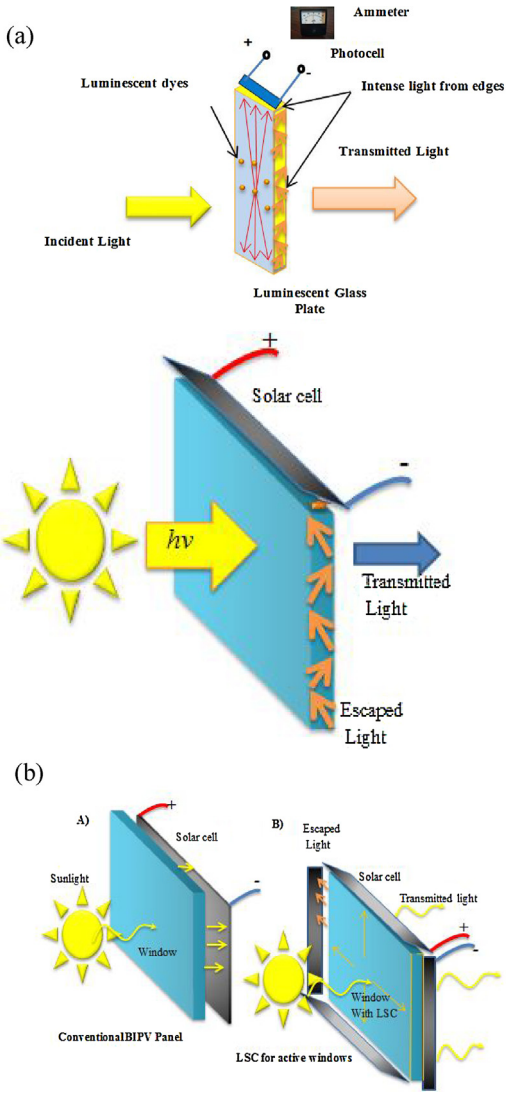

Fig. 1. Principle of Luminescent solar concentrator (LSC) for windows and façades. *A* – The principle, *B* – Difference between Luminescent solar concentrator (LSC) for active windows and BIPV panel.

to BIPV devices where cells are incorporated in the backside of the glass [20,21]. Fig. 1, shows the principle of LSC window and its comparison with BIPV panel. By the application of LSC windows, the integration into architecture and environment seems to be more appropriate to be adapted to any orientation and low radiation [22–24]. Because this kind of technology does not require a specific tilt angle, it is increasingly sought for areas with low radiation as like northern Europe [25,26].

Through this work, luminescent glazing synthesis is experimented by means of a simplified process of dip coating that has been tested and developed at laboratory scale. Achieving a first laboratory prototype permits the study of feasibility and shows the proof of the concept for PV cells monocrystalline silicon type imbedded in the frame borders of the luminescent glass. The various optoelectronic analyses, performed by spectrophotometry and by spectral radiation analysis of light output from edges of the luminescent glazing, helped to understand and highlight the operation of such devices. Furthermore, with varying the light transmission level by adding a tinting film on the backside of LSC window, the conversion efficiency should be enhanced according to the light trapping in the luminescent glazing windows.

2. Experimentations

2.1. Simplified process for luminescent coating of glass plates

After performing various tests, a simplified process using an orange fluorescent pigment component is developed according to the following steps; when mixed with ethanol and distilled water the orange fluorescent pigment is uniformly