Photovoltaic technologies for liquid crystal based smart windows.

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Buildings energy demand represents a huge share of the global energy consumption (40%), ahead of industry (32%) and transport (28%) sectors [1]. This high demand is largely due to the poor thermal and optical performance of traditional windows, which contribute to excessive indoor heating in sunny and hot climates and uncontrolled heat loss in colder environments [2]. To address this issue, current efforts are focused on developing a new generation of adaptive systems known as dynamic glazing or "Smart Windows".

Among them, Photovoltaic Spatial Light Modulators (PSLM) devices stand out for their unique combination of liquid crystal (LC) and organic solar cells (OSC) materials (Figure (a)). Under illumination, the OSC system generates a continuous photovoltage (DC) that can be applied across the LC layer, changing the birefringence of the latter (Figure (b)). In this way, light propagation through the LC media is controlled by the OSC system, making it an optically and self-activated glazing with dynamic properties. For instance, when a PSLM is placed between crossed polarizers and exposed to sunlight, it transitions from a semi-transparent to an opaque state instantaneously (<1s) (Figure (c)). This state can remain stable for several hours after simply short-circuiting the electrodes, without requiring any external power supply. Additionally, by modulating the transmission of solar radiation from the visible to the near-infrared range, PSLM can effectively regulate the amount of thermal energy going inside a room, which is of interest for a smart window technology.

In this work, we present the working principle of a PSLM using an organic-based photovoltaic unit an electrical power source. Then, the current challenges of such system and its interest for further applications will be discussed. Finally, the possibility to integrate alternative photovoltaic technologies in the PSLM concept for smart window application will be explored.

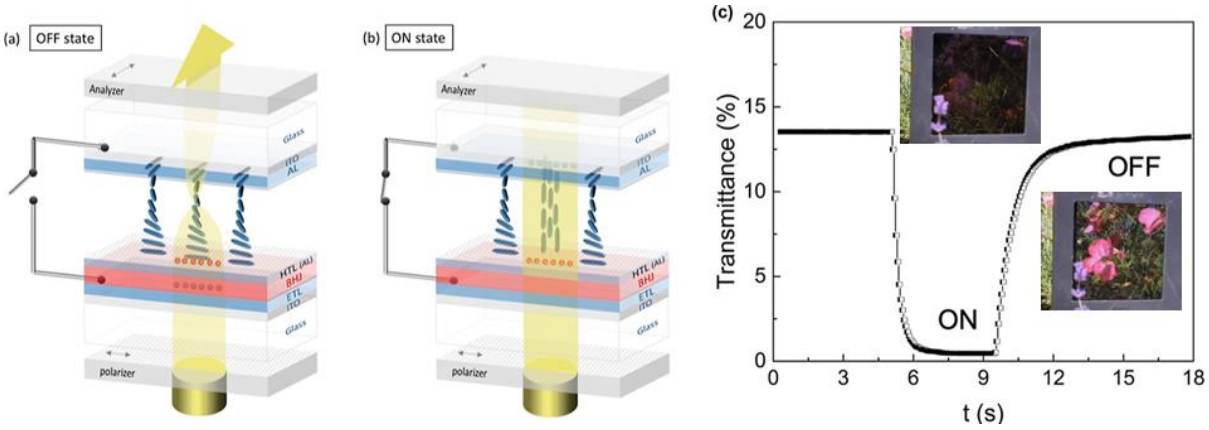

Figure - PSLM under illumination in (a) OFF state and (b) ON state. (c) Transmittance of PSLM between OFF and ON state.

References

[1] Kutscher, C. *The Conversation* (2020).
[2] Rezaei, S. *et al*. *Solar Energy Materials and Solar Cells* **159**, 26–51 (2017).
[3] Fall, S. *et al*. *ACS Appl. Mater. Interfaces* **15**, 4267–4274 (2023).