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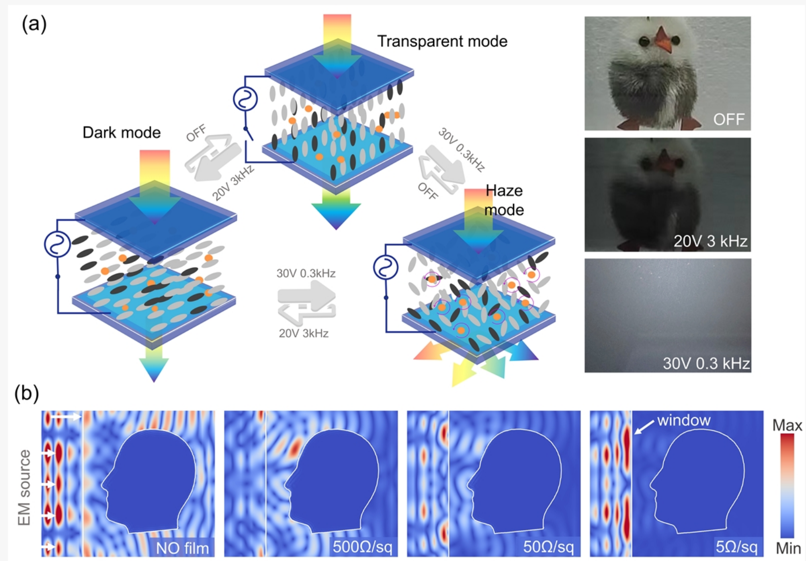
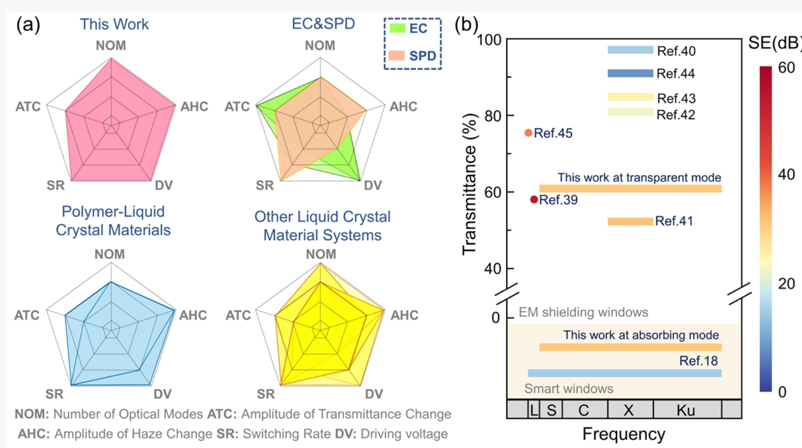
Multispectral Smart Window: A Step Towards Healthier Indoor Environments

USA, September 3, 2024 /EINPresswire.com/ -- A new [multispectral](https://www.maxapress.com/lsa) smart window has been developed, capable of adjusting light transmission and providing robust microwave shielding. Combining liquid crystal scattering with dye doping, this technology allows independent control of transmittance and scattering in a single layer. Operating effectively at low frequencies, it enhances electromagnetic shielding without losing transparency. This breakthrough offers exciting possibilities for energy-efficient and communication-enhancing architectural applications.



a, Schematic diagram of different mode dimming control strategies and effects for the tri-state switching multispectral smart window. b, Electric field analysis of the human head behind the window with different resistance values at 5 GHz wave incidence.

Windows, the vital conduits between indoor spaces and the external environment, also serve as primary entry points for harmful light waves and electromagnetic (EM) waves. However, managing light transmission and scattering typically requires different material systems and devices. Additionally, a critical aspect often overlooked in smart window technology is EM modulation. Therefore, windows capable of visible light regulation and EM shielding are becoming an urgent necessity.



a, Research status of electronically controlled smart windows (EC, Electrochromic smart window; SPD, suspended particle devices). b, Research status of microwave shielding transparent material.

In a new paper (doi: https://doi.org/10.1038/s41377-024-

01541-y) published in Light: Science & Applications, a team of scientists led by Professor Jiaqi Zhu from Infrared Films and Crystal presents groundbreaking research titled "Multispectral Smart Window: Dynamic Light Modulation and Electromagnetic Microwave Shielding". The study introduces an innovative multispectral smart window capable of regulating visible light while simultaneously blocking microwave signals. The structure of this window includes a core liquid crystal mixture composed of negative liquid crystals, ionic surfactants, and dichroic dyes, followed by vertically aligned polyimide layers and indium tin oxide (ITO) film, all encapsulated within a glass substrate.

As shown in Figure 1(a), combining dynamic scattering and liquid crystal doping achieves precise control over transmittance and scattering, ensuring better energy savings and privacy protection. Furthermore, optimizing the ITO film thickness provided effective microwave shielding without sacrificing optical performance, reducing potential health risks brought about by the rise of 5G networks, as shown in Figure 1(b).

Comparing existing electronically controlled smart windows and transparent structures for microwave shielding technologies, this study demonstrates significant advantages in five dimensions: response time, transmittance adjustment range, haze adjustment range, driving voltage, and optical modulation mode, as shown in Figure 2(a). As shown in Figure 2(b), compared to existing transparent electromagnetic shielding materials, this study exhibits superior performance across the covered shielding bands, including S, C, X, and Ku bands. Moreover, the electromagnetic shielding effect of this approach significantly surpasses that of commercially available PDLC materials.

In summary, this study presents a novel multispectral smart window technology designed to mitigate electromagnetic pollution while dynamically adjusting incoming sunlight through transitions between transparent, absorbing, and haze states. With the help of the proposed ion movement model and dielectric constant operation strategy, the ratio of CTAB and SDS was determined to achieve a lower optimal driving frequency (~300Hz), thereby avoiding electrical breakdown that is more likely to occur under high-frequency driving. Additionally, by optimizing the thickness of the transparent conductive film, the broadband electromagnetic shielding effect was significantly improved to 30.9dB, while minimizing the impact on optical transparency. This research provides a beneficial attempt at coordinating the design and optimization of smart windows for both solar spectrum and microwave spectrum management.

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