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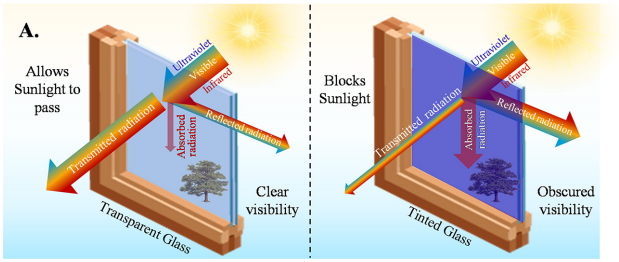
Microscopic structural changes in windows can modulate the amount of heat and light throughput, but optimal application requires an in-depth understanding of the material's optical properties.



Tunable windows can change their optical properties to modulate transmittance. By controlling how much heat and light enter and escape, they provide privacy, increase comfort, and conserve energy. The emerging technology could be used in vehicles and buildings and is especially relevant for skyscrapers.

However, commercial tunable windows are far from perfect: much work remains to develop reliable, long-lasting, and high-performance devices.

Shrestha et al. explored how microscopic changes in topography, orientation, and phase of non-exotic window materials can create micro-reflectors, absorbers, and scatterers to control light transmission over large areas.

"To harness the full potential of such technologies for various real applications, their optical principles must be understood in depth," said author Milan Shrestha. "Therefore, our review paper has categorized these emerging technologies based on the various optical principles involved, including light absorption, reflection, particle scattering, and surface scattering."

A tunable window's optical transparency and operational light frequency range dictate its potential applications. Optical transparency is mostly characterized by specular transmittance and determines the energy throughput. Tuning different regions of the light spectrum makes windows suitable for energy conservation in the infrared and privacy preservation in the visible.

"Existing individual tunable window technologies cannot fulfil all the requirements expected from a tunable window," said Shrestha. "Learning and categorizing the devices based on optical principles will allow their proper use based on the application. Furthermore, this allows inventors and researchers to optimize, improve, and even combine these devices to make them multifunctional."

The researchers are currently working to develop smart windows that can tune optical transmittance and absorb noise smartly by adapting to changing noise frequency.

Source: "Emerging tunable window technologies for active transparency tuning," by M. Shrestha, G. K. Lau, A. K. Bastola, Z. Lu, A. Asundi, and E. H. T. Teo, *Applied Physics Reviews* (2022). The article can be accessed at https://doi.org/10.1063/5.0089856.