Prospective of
Smart Windows
in
Indian Railways

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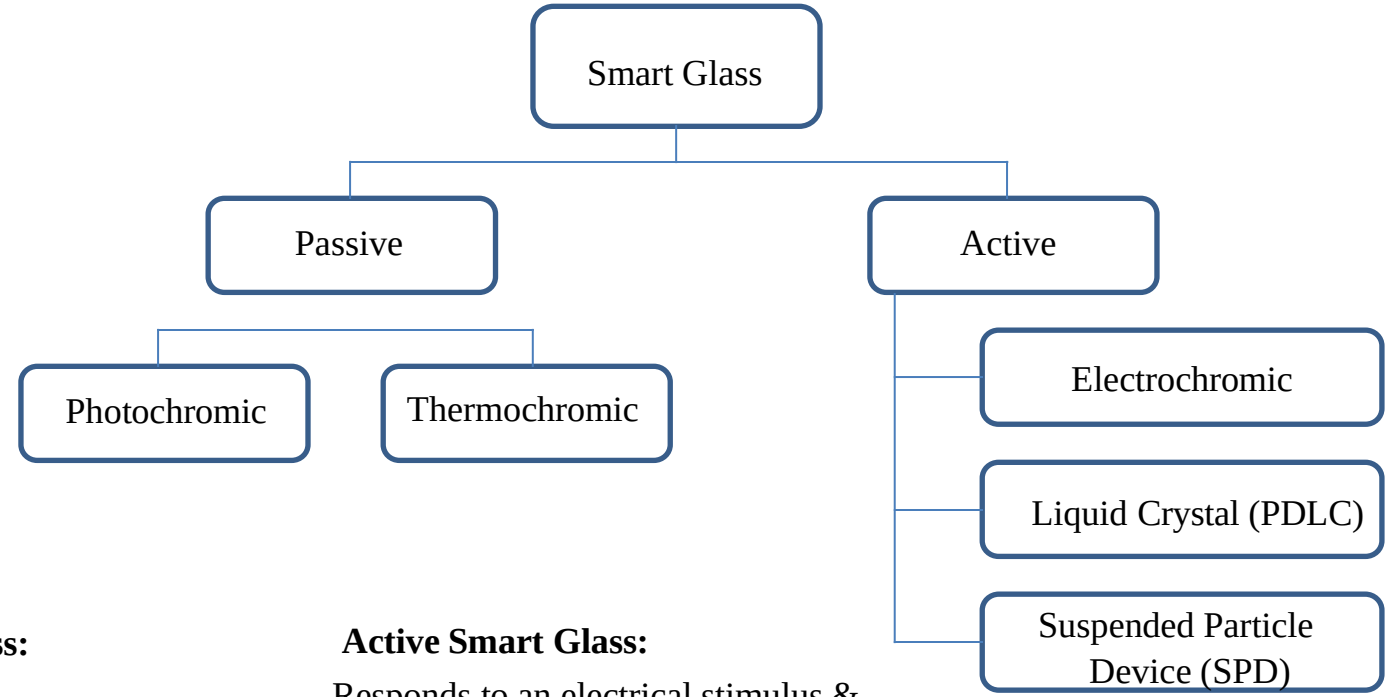
Overview

- Smart glass film is intended to have the ability to control the amount of light, and heat, passing through. With a switch of a button on a wall or smart phone app, the glass can change from transparent to completely opaque.

Types of Smart Glass



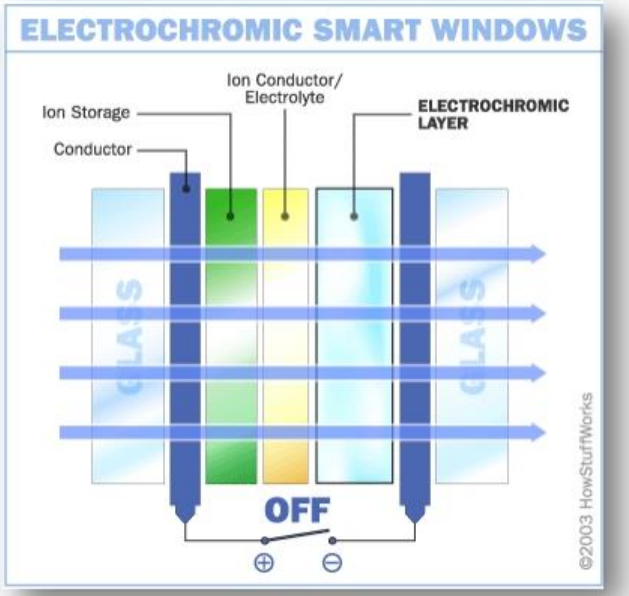
Passive Smart Glass:

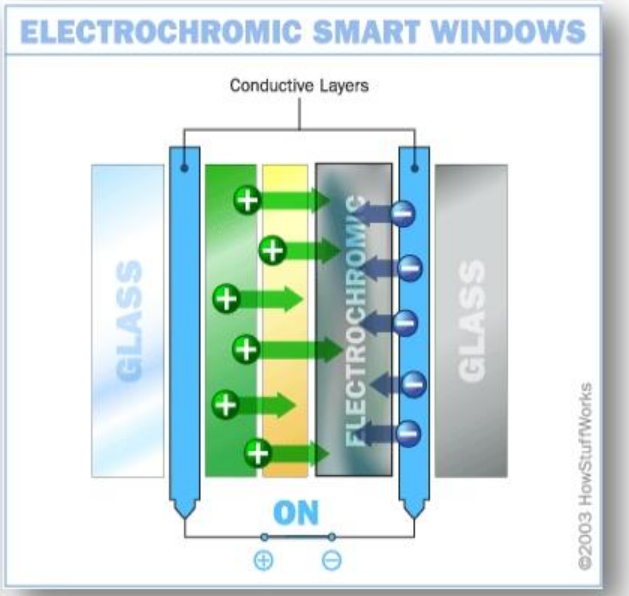
Responds to non-electrical stimuli (heat, UV). Cannot be manually controlled

Active Smart Glass:

Responds to an electrical stimulus & and is controllable manually or automatically

Active: Electrochromic





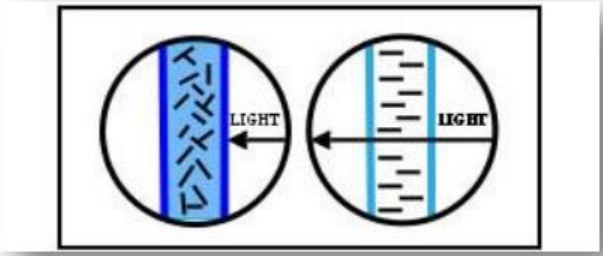
Active: Electrochromic

- Consists of two glass panes with several layers sandwiched in between. It works by passing low-voltage electrical charges across a microscopically thin, clear conductive coating on the glass surface, which activates electrochromic layers that change color from clear to dark.

- One advantage of the electrochromic smart window is that it only requires electricity to change its opacity, but not to maintain a particular shade.

- The switching speed of electrochromic glass is very slow and varies depending upon the size of the panel (larger panels typically take many minutes to switch). The consistency of tint changes also varies, with larger panels sometimes exhibiting tint changes that begin at the glazing's outer edges and then move inward (known as the "iris effect").

Active: Suspended Particle Device (SPD)



- In suspended particle devices (SPDs), a thin film laminate of rod-like nano-scale particles is suspended in a liquid and placed between two pieces of glass or plastic, or attached to one layer.
- When no voltage is applied, the suspended particles are randomly organized, thus blocking and absorbing light. When voltage is applied, the suspended particles align and let light pass. Varying the voltage of the film varies the orientation of the suspended particles, thereby regulating the tint of the glazing and the amount of light transmitted.
- The visible light transmission at the darkest state of SPD glazing is around 0.5% and the process takes one to three seconds after power is applied, regardless of the size of the window.

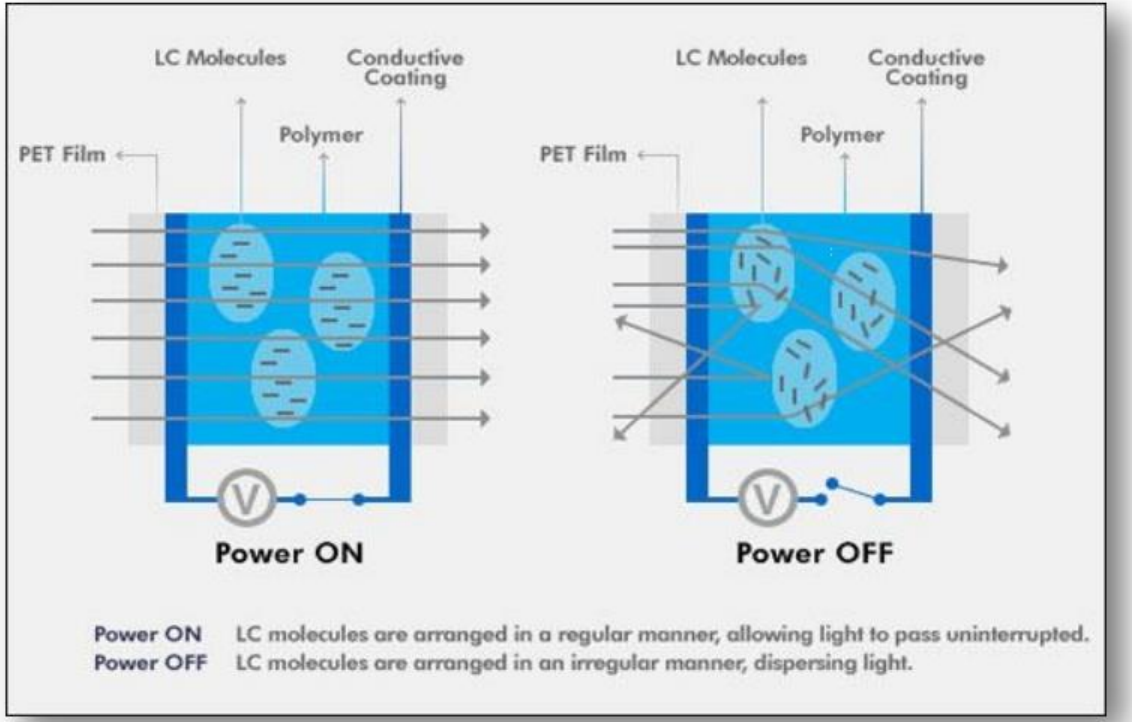
Active: Polymer Dispersed Liquid Crystals

(PDLC)

- Polymer dispersed liquid crystal is simply micro droplets of liquid crystals encapsulated in a polymer matrix.
- Inside the film, structure are two optically clear, sputtered transparent conductive layers of Indium Tin Oxide, “ITO”
- The liquid crystals respond to an electrical charge. In a static state, the liquid crystal molecules remain in a randomized configuration that refracts the light that enters the mixture, making it appear opaque. When electricity is applied, the molecules line up the direction of the electric field, allowing light to pass through what is now essentially a transparent surface.

Active: Polymer Dispersed Liquid Crystals

(PDLC)



PDLC vs. Electrochromic Technology

PDLC Technology

- Can be used for interior or exterior glass applications.
- Switches from opaque (milky white or gray) to clear in less than a second.
- Can run on standard 110-volt AC.
- Available in a self-adhesive switchable film that can be applied to existing window surfaces.
- Provides total privacy in its opaque state (cannot be seen through).

- **Electrochromic Technology**
  - Used for exterior glass applications, for solar control.
  - Not used for interior privacy
  - Long transition time from clear to opaque. Larger windows can take five to 20 minutes.
  - New glass must be installed; no film option for existing glass.
  - Not used for privacy as you can still see through it in its dark (tinted) state.

Value proposition in Railways installations

From Indian Railway Prospective

- Long durability
- Reduced power consumption
- Controller's minimal footprint: small size, low weight - easy to connect, install & hide
- Improved protection of PDLC film (thanks to the Square wave system used by our controllers: over-voltage/DC blocking/short circuit, power surge)
- Safe to use UL/CE compliance of all our controllers
- The film can be easily cleaned
- Easy maintenance
- System approach providing full solution including film, controller and technical support
- Reliable warranty

Passenger/end user

- Privacy with a flick of a switch (switching time in milliseconds): the customer can decide to have an opaque window when in a train station.

- Passengers can enjoy view out of the window thanks to the film high transparency

- High technology: ability to connect to smart advanced operating system

- Premium User Experience

Typical Parameters

Specifications

Parameter	Value	
	OFF	**ON**
Appearance	Translucent	Clear
Parallel Visible Light Transmittance	3%	78%
Total Visible Light Transmittance	65%	81%
Haze	>99%	3%
Switching Time	OFF ▶ ON 10 msec	ON ▶ OFF 150 msec
Operating Modes	ON/OFF, Dimmer	
Operating Voltage	70 VAC sq wave	
Operating Frequency	25-30, 32, 50-60 Hz	
Power Consumption	2-4 W/m²	
Film Thickness	275 micron (10mil)	
SR hardcoat Taber Abrasion Resistance (ASTM D1044)	ΔHaze < 2%	
PS adhesion strength	600-800 gr/in	
Operating Temperatures	14°F - 158°F (-10°C- 70°C)	

Comparison to Venation Windows

- ☐ No Moving parts
- ☐ More Reliable
- ☐ Retrofittable.
- ☐ Standard Smart Film
- ☐ Lesser Life Cycle Cost

Thank You