Course Name: Building Materials as a Cornerstone to Sustainability

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Lecture 02

Electrochromics

Hello everybody. Last class we looked at two smart materials mechanochromics and chemochromics. These are materials which react to changes in mechanical pressure and changes in chemicals. We saw the basics of these materials. We also saw the general uses of these materials. we saw what happens as a consequence of I mean what is the stimulus that gives the particular reaction and we saw the small architectural applications wherever possible we saw that.

In the same line today, we will see electrochromics as a smart material. And in today's class, we will see a small introduction about electrochromics, the application of electrochromics on devices, its characteristics, the benefits, the limitations, the applications and application of electrochromics on buildings, or its architectural application. Now, in the realm of electrochromics, materials undergo colour changes in response to an electric potential—a phenomenon extensively employed in mirrors and windows for anti-glare purposes. This electrochemical reaction known as electrochromism brings about a reversible and visually perceptible modification in transmittance and reflectance or just reflectance.

Notably, this optical transformation is achieved with a low-voltage electric current, facilitating dynamic and adaptable alterations in color. This technology finds practical applications in creating dynamic and efficient optical solutions for various devices, offering versatility and improved visual experiences. Let us look at the application of electrochromics on devices. Electrochromic devices find application in smart windows and display. The assembly process involves preparing FTO glass here.

It involves the preparation of the glass; the initial glass is coated with tin oxide, the soft echoing of tin oxide enhancing the substrate. The assembly process involves preparing FTO glass with SnO_2, tin oxide which is also known as stannic oxide. fluorine coating, soft echoing for substrate enhancement happens, electrochemical deposition of nickel hydroxide coated with polyvinyl alcohol film, introducing a silver coated copper wire and placing additional materials for colour representation. The final stage includes sealing the device edges with thermal adhesives. This stepwise process ensures the efficient functioning of electrochromic devices, allowing for dynamic changes in optical properties and enabling applications in energy efficient building system and electronic displays.

Let us now look at the characteristics of electrochromics. If we look at the basic design, electrochromic coating includes a transparent top electrode injecting electrons into the underlying layer. The key material is tungsten oxide. Tungsten oxide is a promising electrochromic material offering high coloration efficiency and capacity. It has solar control materials.

Inorganic materials like tungsten oxide, nickel oxide, etc. are often doped with lithium or hydrogen. They are developed for solar control. There is an ion conduction layer. Ion conductors including solvent polymer systems, ionic glasses and metal oxide structures transport protons into the electrochromic material.

The transparent conducting bottom layer This is another transparent conducting coating that injects electrons and protons, inducing color change in the electrochromic material. Then there is a color change mechanism. External electric field control induces a strong absorption band, resulting in color change in the visible spectrum. Then we have the operational principle. External electric field controls injection with coloration persisting and reverting to the initial state upon reversal of polarity.

So electrochromic things are like magic color changing materials. They have a clear top part that sends in tiny particles called electrons. Special materials like tungsten oxide are like the stars because they can change color really well. But scientists have also used other materials like nickel oxide or other chemicals to control sunlight. There is a layer that helps move tiny particles and other clear layer that adds more particles to make the colours.

When we use an electric field, it's like a remote control making the colours to change. The best part is if we change the remote control, the colours go back to normal. It's like having a magic colour switch. Switch on, switch off and the colour changes. What are the benefits of electrochromics? So they offer a lot of benefits.

First, they save energy because they only need power when changing colours. So, they require power only during the switching process and they contribute to overall energy efficiency. Second is low switching voltage. They work with low voltage, just 1 to 5 volts. So, they don't use much power.

Third is specular reflection. They have fancy reflection that makes things look clear and nice. And these exhibit specular reflection, enhancing optical properties and visual clarity. Fourth is they have grayscale capability. They possess a grayscale enabling a range of color intensities.

So, they can show different shades of colors, like a cool gray scale. Lastly, they remember their colors for a long time. They have adjustable memory. They can remember the colors even for 12 to 48 hours.

They can retain. So, you don't have to keep changing them. Overall, electrochromics are a very new and innovative way of saving energy. They look aesthetically pleasant and gives us a lot of color options. What are the limitations of electrochromics? So first is the cost consideration. The initial cost can be relatively high affecting widespread adoption.

The second is the durability challenge. Durability issues may arise, impacting long-term performances. Third is response time variability. Response times to environmental changes may vary potentially causing uneven tinting. Fourth is the complexity in manufacturing.

The manufacturing process can be complex, leading to technological challenges. And last is the limited use in architecture. Limited adoption in architecture is due to the high cost, technological complexity and challenges in uniform substance distribution within glass panes. So using electrochromic things comes with its own set of challenges. First, they can cost a lot at the beginning, making it harder for everyone to use them.

Second is they might not last a really long time, affecting how well they work in the long run. Third, they might not change colours at the same speed at all, causing uneven colours. Fourth is making them is not easy which brings technical problems. Lastly, they are not used a lot in building design primarily because of their high cost, technical problems, and issues with making the colours even across glass windows. Despite these challenges, researchers are working hard to make them better so that they can be applied in the architecture and building construction industry because eventually the big advantage they give is energy efficiency.

And in order to move towards sustainability, it is important that we adopt this in architecture. Let us now look at applications of electrochromics. So, first is versatile electrochromic devices. These are widely used in large area switching for building, automotive, mirrors and glazing applications. Second is diverse applications.

These extend to specialized displays, electronic books, paper-like screens, and banner displays. Third is plastic substrate advantage. Chromic materials applicable on plastic substrates offer flexibility for future display applications. Next is Siemens' innovation. Siemens has developed a paper-thin electrochromic display with printed circuit control aiming for low-cost manufacturing.

Fifth are textile-integrated displays. France Telecom integrates flexible battery-powered optical fiber screens into clothing for dynamic displays. Then electric plate trademarked by IFM. IFM's electric plate combines textile display technology and design material, allowing programmable color changes. Then there are electrochromic inks in textiles.

These find applications in textiles such as jackets displaying pictures intermittently showcasing wearable technology versatility. So electrochromics have exciting uses in various fields. They are commonly employed in large-scale applications like buildings, cars, mirrors, and windows. Beyond that, they bring diversity to special displays, electronic books and innovative banner displays. The magic lies in their ability to work on flexible plastic, opening doors for future displays and advancements.

Siemens have even created a super thin electrochromic display for low-cost manufacturing. The French telecom embedded optical fiber screens into clothing for dynamic display. Even jackets with electrochromic inks are showcasing wearable tech's versatility. So, the electrochromic devices with nanostructural materials finds usage in energy storage, in smart windows, in wearable electronic displays, in electronic labels, in anti-glare rear view mirrors and as electronic skin. Now, let us look at the applications of electrochromics in architecture or building specifically.

So, electrochromics have come a long way, especially in building applications. Initially explored for displays in the 1980s, they faced durability issues leading to the dominance of liquid crystals. However, the 1990s witnessed a resurgence with aerospace, aviation and automotive sectors showing interest. Now electrochromic materials are integrated into glass, creating smart windows for buildings. This electrochromic glazing adjusts transparency, blocking harmful solar radiation and reducing overheating, making buildings energy efficient.

Asahi Glass Company pioneered electrochromic glass in the year 1988, used in the Seto Bridge Museum. This case study We see that there is a resurgence in the 90s with interest in electrochromic materials surged in the early 1990s, particularly in aerospace, aviation and automotive sector. electrochromic materials in thin layers are integrated into insulating or laminated glass, creating smart or switchable windows. EC glazing, or electrochromic glazing's appeal lies in adjusting transparency to visible and infrared solar radiation, preventing greenhouse effects in buildings. The various solar radiation transmission in the infrared range, reducing overheating and energy consumption for cooling in buildings make electrochromics an energy efficient solution.

There have been many early adopters, but a lot of research remains to be done in this area and domain, especially its application in the field of architecture. So, more research in this field will lead to its applications, wider applications in architecture. All of this would lead to energy efficient buildings. So, today we will stop our class. with this topic on electrochromics, which is an upcoming material with its application in architecture and building construction.

We will meet again in the next class with another smart material. Thank you.