Docket #: S17-215

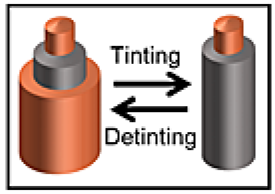
Fast, Uniform, Reversible Electrodeposition for Large Scale Energy-efficient Dynamic Glass

Researchers in Prof. Michael McGehee's laboratory have developed a glass architecture that employs reversible metal electrodeposition for fast-switching smart windows with high contrast ratio and durable cycle life. Dynamic glass smart windows control solar radiation by switching from transparent to opaque. However, conventional smart window technologies are not commercialized on a large scale due to problems associated with color, cost, durability and switching speed.

This invention solves those problems by reversibly electroplating metal over a large area using a durable, invisible metal grid applied to a transparent electrode substrate. The substrate is pre-treated to modify the surface and promote uniform deposition of the opaque metal so that when voltage is applied the substrate converts from transparent to opaque and everything in between within seconds. The glass then maintains either a clear or neutral-colored opaque state without drawing any power.

The optically dynamic components of this glass could be deposited on an industrial scale with a solution-based process which is expected to substantially lower costs compared with transition metal oxides. This technology offers a promising alternative to electrochromic materials or transition metal oxides for large-scale smart windows to provide reliable control of solar radiation.

Dynamic Window with Metal Electrodeposition: *Glass reversibly switches from transparent to opaque and back when voltage is applied.*



Cross section of metal grid architecture: *Uniform opacity switching is achieved using a grid consisting of a metal core conductor (orange), surrounded by an inert metal (gray) which is covered by the electroplating outer layer metal that tints and detints the surface upon application of voltage thereby changing the opacity of the substrate.*

Stage of Research

The inventors have demonstrated the proof-of-principle for opacity switching with gridlines on two 5 cm x 5 cm prototype windows using a modified ITO electrode. These windows uniformly switched between a transparent state (~80% transmission) and opaque state (5% transmission) in less than 3 minutes. The inventors continue to research scaling to larger windows and optimizing the metal grid to reduce “irising”.

Applications

- **Smart windows/dynamic glass** - glass with electronically-controlled opacity with end user applications such as:
  - residential and commercial buildings
  - automotive/vehicle glass
  - aerospace
  - electronics/optoelectronics
  - switchable sunglasses

Advantages

- **Fast, uniform and reliable switching:**
  - less than 3 minutes to switch from transparent to opaque or vice versa
  - uniform transparency across large surface area
  - cycles at least 5500 times without degrading uniformity, optical contrast or switching speed
  - great resting stability

    - reversible (99.9% Coulombic efficiency)
- **Reduced costs with solution-based fabrication:**
    - optically dynamic components could be deposited on an industrial scale by soaking the substrate in a series of chemical baths
    - no expensive vacuum deposition
    - expect dynamic windows with non-toxic gel electrolyte will be substantially lower cost than those with transition metal oxides
- **Neutral color with tunable transparency:**
    - opaque color appears black (not blue) and offers high privacy
    - can switch from clear to opaque and everything in between
- **Energy-efficient** - stays in previous state at open circuit, thereby maintaining state (clear or opaque) without using power

Publications

- Mark Schwartz, "Stanford engineers create smart windows that go from clear to dark in under a minute," Stanford Report (Aug. 10, 2017)
- Barile, Christopher J., et al. "Dynamic Windows with Neutral Color, High Contrast, and Excellent Durability Using Reversible Metal Electrodeposition." *Joule* (Aug 9, 2017).

Patents

- Published Application: 20200142273
- Issued: 11,292,029 (USA)

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