How Window Glass Is Getting Smarter

A material that selectively blocks heat and light could finally make it practical to add smart windows to buildings.

- By Mike Orcutt on September 9, 2013

Why It Matters

In the U.S., 30 to 40 percent of all energy use is associated with buildings.

Heliotrope Technologies, an early-stage startup currently incubating at Lawrence Berkeley National Laboratory, may have found the key to delivering the first cost-effective "smart window." The company has developed a relatively inexpensive glass composite with the unprecedented capacity to selectively block the sun's heat-producing infrared radiation as well as visible light. Buildings equipped with such glass could be more energy-efficient.

The company recently announced that it would begin sending samples to large glass manufacturers to "evaluate its potential for commercial and residential buildings." It aims to produce its first product within three years.

Many experts see the emerging technology of "smart" or "dynamic" windows—which use glass whose transmittance of solar radiation can be changed on demand by applying heat (thermochromic), light (photochromic), or electricity (electrochromic)—as a promising way to curb the consumption of energy for cooling and lighting buildings. The National Renewable Energy Laboratory has estimated that widespread use of the technology could save around 5 percent of the total U.S. energy budget. The market for smart glass remains minuscule, however, and is mostly confined to niche applications like tintable rearview mirrors in cars. Demand for smart windows is low because the upfront costs are prohibitively high for most potential buyers.

Two companies, View and Sage Electrochromics, have taken the lead in the fledgling industry. The latter was recently acquired by major glass manufacturer, Saint-Gobain. But the first-generation products these companies are making mainly modulate visible light, and any small variation in their ability to block infrared (IR) radiation can only occur at the same time that visible light is also blocked, says Delia Milliron, a Heliotrope cofounder, the company's chief scientific officer, and staff scientist at LBNL. "There's no separation as a function of voltage that we have in our materials."

Milliron's group at LBNL published a paper last month in *Nature* in which it described a new glass composite material that can be reversibly tinted and can block infrared radiation while remaining transparent—the first demonstration of glass that allowed for independent control over the transmittance of visible light and IR radiation. The new material can switch between three modes, in fact—fully transparent, transparent but blocking IR radiation, and blocking of both visible and IR radiation—according to the amount of applied voltage. And once the glass has switched, it is no longer necessary to run current through it.

An electrochromic window essentially works like a transparent rechargeable battery. Two pieces of conducting glass sandwich an electrolyte material, and changes in transmittance of the glass occur in response to electrochemical charging and discharging.

In the design demonstrated by Milliron's group, the new composite, made of indium tin oxide nanocrystals embedded in niobium oxide glass, is deposited on one side and serves as an electrode; another electrode is placed on the opposite side of the electrolyte. Applying a moderate voltage causes the nanocrystals to become electronically charged, which in turn causes IR radiation to be absorbed and blocked. Applying a somewhat larger voltage causes the niobium oxide glass to become electrochemically reduced, which results in tinting. Finally, another modest voltage makes the glass switch back to fully transparent.

While Heliotrope isn't using the exact materials employed in Milliron's published research, the company's proprietary compositions are "similar" to those her group has demonstrated, says cofounder and president Jason Holt.

The powerful new functionality of Heliotrope's material is not even its most important distinguishing feature, at least in the near term, according to Holt. "I think what's really going to expand the market for smart windows is a product that's much cheaper than what's out there."

The products that View and Sage are making are about twice as expensive per square foot to the end-user compared to a typical static, double-paned window, he says. Since Heliotrope's material can be made using relatively low-cost solution deposition techniques, and doesn't require the more expensive vacuum deposition techniques generally used to make electrochromics, Holt believes the company can eventually make products with prices more in line with those of the standard double-paned windows. "That's where you need to be if you want to start looking at these as energy-efficiency products, and subjecting them to energy payback metrics and stuff like that."

Current smart glass products are so expensive, and the payback period for them is so long, that "buying smart glass purely on the basis of its energy efficiency is not something that's really happening today," says Eric Bloom, a senior analyst at Navigant Research who recently authored a report focused on the smart glass market. In fact, for the next few years, as Sage and View ramp up their manufacturing capacity, the market will likely be driven mostly by buyers who can afford to buy smart glass simply because "it's cool," says Bloom. Costs are coming down, though, and from an energy savings perspective, he says, "the business case for smart glass will look a lot more compelling in about five years."

For now, Heliotrope will focus on adapting its fabrication technology to make prototypes measured in square feet instead of square inches. If all goes as planned, says Holt, the company will be making "small form factor" devices, perhaps as large as a skylight window, within about two and a half years.

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