Nanocrystal-based electrochromic windows

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Buildings represent the single largest contributor to energy consumption in the U.S. (40%) and electricity use is dominated by buildings (71%). While a variety of end uses contribute to these aggregate figures, lighting and HVAC (heating, ventilation, and air conditioning) stand out as universal and large energy consumers, together accounting for the majority of energy used by both commercial and residential buildings. Windows have a substantial impact on both lighting and HVAC energy use, historically representing an energy liability due to poor thermal barrier properties and poor management of passive solar heating. Modern dual pane windows and spectrally selective window coatings have greatly reduced the energetic cost of a nice view, but more work remains to make windows a net energy asset.

Our work is part of a broader effort to develop dynamic window coatings that respond intelligently to daily and seasonal changes in the outdoor environment, greatly improving on energy savings made possible by today's optically static coatings. Electrochromic materials change their optical transmittance on-demand under applied bias, which makes them particularly attractive for integration with emerging whole-building control systems. However, the electrochromic windows now emerging on the market modulate both visible and near infrared (NIR) light transmission together, with the greatest dynamic range on the visible region. While effective for glare control, these optical properties are not ideal for energy savings since lighting and heating needs cannot be separately addressed.

We are developing nanocrystal-based electrochromic coatings that selectively modulate NIR transmittance while maintaining near unity transparency for visible light. The active material is a film consisting of a conducting network of transparent conducting oxide nanocrystals. The free carriers give rise to a fall off of transmittance in the NIR, which is tunable by synthetically adjusting the doping level. Positioning the film as the working electrode in an electrochemical cell, we can modulate NIR transmittance dynamically since the carrier population changes in response to an applied bias. Analysis of cyclic voltammetric data reveals a capacitive response, implying that cation intercalation is not necessary for efficient NIR coloration. This is in contrast to conventional electrochromics, which can eventually fail due to the stress of repeated intercalation/deintercalation cycles. Work is underway to optimize the dynamic range of transmittance for solar NIR radiation in order to establish a clear pathway to a unique window coating technology capable of on-demand passive solar heating with continuous daylight illumination.

This work was supported by the U. S. Department of Energy (DOE) though an Early Career Research Program award (D.J.M.) and the LDRD program at LBNL under Contract No. DE-AC02-05CH11231. The work was conducted at the Molecular Foundry, a DOE user facility located at LBNL.