Chemical Engineering Distinguished Young Scholars Seminar

Nanocomposite Architecture for Energy-Saving Electrochromic Smart Windows

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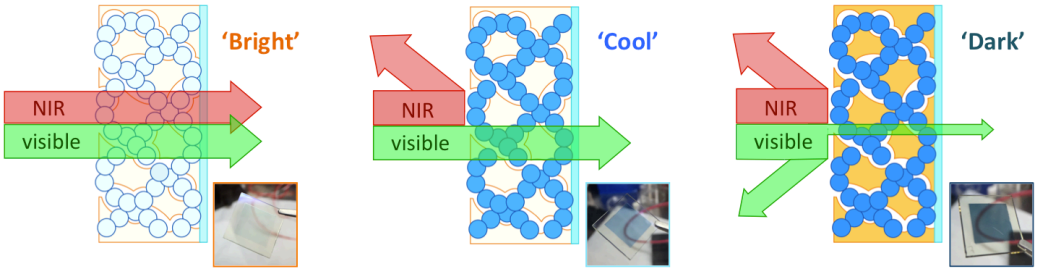
Date: Monday, July 13, 2015
Time: Lecture: 4:00-5:00 p.m.
Place: PAA A110
Happy Hour in Benson Hall Lobby

Abstract

Heating, cooling, and lighting in buildings account for 24% of the total energy consumption in the US. If near infrared (NIR, heat) and visible (VIS, light) solar radiation through windows can be actively and independently controlled in response to exterior conditions, this enormous energy demand can be significantly reduced. We present the design and fabrication of a new electrochromic material that performs near-ideal solar modulation.



Recent studies on NIR-plasmonic nanocrystals opened a new possibility of NIR-selective electrochromism by a reversible switching of plasmonic light extinction via electrochemical charging and discharging. The target wavelength range of localized surface plasmon resonance (LSPR) can be fine-tuned by selecting the nanocrystal matrix and dopants[1]. Among a variety of doped metal oxide nanocrystals that we have synthesized, vacancy-doped tungsten oxide (WO_{3-x}) exhibits an intense LSPR absorption well-tuned to match the solar NIR radiation (700~1300 nm).

To realize independent modulation of NIR and VIS transmittance through windows, we fabricated a composite film consisting of these WO_{3-x} nanocrystals and a conventional VIS-electrochromic material, niobia glass (NbO_x). The inherently different switching potentials of WO_{3-x} and NbO_x is a prerequisite to NIR-VIS dual-band switching[2]. However, a judicious arrangement of the two components was essential to avoid deleterious interactions such as blocking of charge transport pathways. Our nanocomposite architecture comprises a mesoscale WO_{3-x} framework, interpenetrating NbO_x domains, and small mesopore channels introduced at the WO_{3-x}-NbO_x heterointerface. The high density of the heterointerface and the open pore channels allow efficient electrolyte percolation promoting exceptionally rapid and independent charging and discharging of each component. Moreover, enhancements in charge capacity, optical contrast, and cycling durability (>2000 cycles) were also observed. In result, we achieved unprecedented modulation of thermal loads at the 'Cool mode' ($36\%T_{NIR}$: $73\%T_{Vis}$), while the neutral color 'Dark mode' ($7\%T_{NIR}$: $22\%T_{Vis}$) rivals the best tinting performance of VIS-switching windows commercialized today[3].

[1] Lounis, S. D., Runnerstrom, E. L., Bergerud, A., Nordlund, D. & Milliron, D. J., *J. Am. Chem. Soc.* **136**, 7110-7116

[2] Llordes, A., Garcia, G., Gazquez, J. & Milliron, D. J., *Nature* **500**, 323-326

[3] Kim, J., Ong, G. K., Wang, Y., LeBlanc, G., Williams, T. E., Mattox. T. M., Helms, B. A., Milliron, D. J., *Submitted to Nature Materials.*

Bio

B.S. (2006) at KAIST (Korea Advanced Institute of Science and Technology) - Dept. ChemE & Biomolecular Engr. M.S. (2009) at Ecole Centrale Paris (France) - Dept. ChemE, Research staff (2010) at KIST (Korea Inst. of Science and Technology), PhD (2013) at Ecole Polytechnique (France) - Materials Science, Postdoc (2014) at Lawrence Berkeley National Lab and (2015) at U of Texas at Austin - Dept. Chemical Engineering.

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