DESIGN OF CERAMIC-POLYMER OPTICAL COMPOSITES FOR BUILDING ENERGY EFFICIENCY INFRARED PROPERTY CONTROL AND TRANSPARENT BULK THERMAL INSULATORS

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Of ~$1 trillion total U.S. energy use, 15% is for heating, ventilation and air conditioning, and over 20% of this energy, 3.4% of total US energy, goes out the window through thermal losses, equivalent to $34 billion of energy waste annually. Materials design of windows, roofs and insulation is an opportunity for energy efficiency improvements, by optimizing solar absorption, transmission, infrared emission and thermal insulation. This presentation will discuss both static and dynamic/active approaches to improved energy efficiency in windows through materials design and performance improvements.

Topics will include:

- The solar spectrum and design of materials for windows to optimize UV/visible/infrared properties
- Approaches used for high performance static windows
- Emergence of dynamic (electrochromic, thermochromic) window technologies
- Approaches to minimize thermal conductivity in transparent materials
- Ceramic-polymer composites developed for energy efficient windows and future prospects.

Several groups in the U.S., including ours, have recently worked under the ARPA-E SHIELD program (Single-pane Highly Efficient Lucid Designs) on development of new materials for high efficiency window technologies including aerogels, optimized visibly transparent but infrared reflective coatings, and dynamic materials. In our presentation we will discuss new approaches to window materials as well as our development of two novel materials: thermochromic nanoparticle coatings and nanostructured, visibly transparent polymers.

Thermochromic materials enable environmentally-tuned windows – high infrared gain during cold temperatures and high infrared reflectivity/emission during warm temperatures. Nanostructured polymers have been developed as low cost, flexible, visibly transparent low thermal conductivity films as an alternative to aerogel technologies.

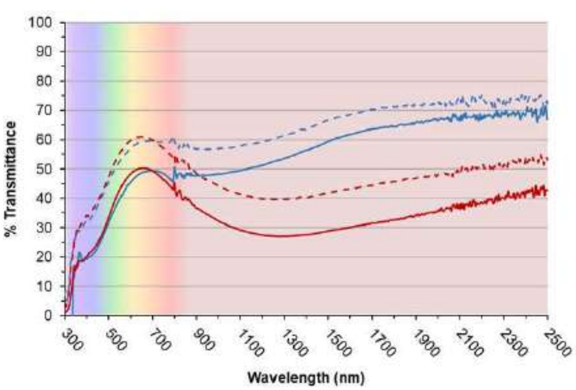

Figure 1 –Cold (top) vs. warm (bottom) transmission of thermochromic VO_2 films

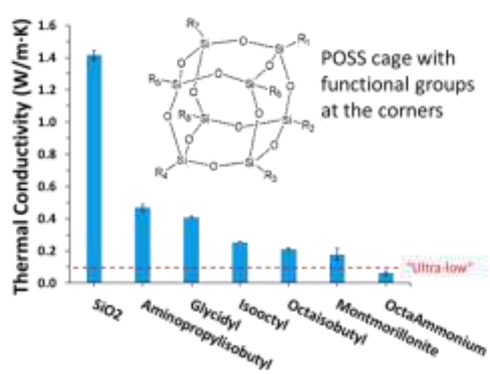

Figure 2 – Low thermal conductivity of POSS polyhedral oligomeric silsequioxanes

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