

A Green Nanotechnological Approach for Energy Efficiency and Conservation: Tungsten-Doped Vanadium Dioxide Thermochromic Smart Windows

Chen, Cynthia (School: Greenwich High School)

Vanadium dioxide is a "functional material" that has gained notoriety in fundamental research and smart-window applications. It responds to environmental temperatures, making reversible structural changes from an infrared-transparent semiconducting state to an infrared-translucent metallic state when heated beyond its transition temperature (T_c). Application of VO₂-thermochromic smart windows has been limited, however, due to T_c values higher than desired ambient temperature. In this research, tungsten-doped VO₂-windows were synthesized, to lower the transition temperature to <30°C, and improve the transmission properties. The temperature-dependent optical properties of windows were studied from 400-4000nm via visible, near-infrared, and mid-infrared spectroscopies. Their ability to control infrared light transmission as a function of outside temperature was determined via thermal imaging. Results for the 1.7%W-VO₂ window highlight %Transmission decreases of 25.3% and 42.8% through the near-infrared and mid-infrared regions, respectively, with heating from 29-60°C. Decreased transmission of W-VO₂ windows is evident via a decreased thermal footprint; as the sample temperature was raised from 20-60°C, the VO₂ window reached 58.1°C, determined by radiation, while the 1.7%W-VO₂ windows reached only 37.9°C. Finally, modeling of overall increase in room energy efficiency was performed using 8in3 model-wooden homes, with W-VO₂ (and control) windows, and constant infrared illumination. With an increase in the external window-temperature from 29-60°C, the home temperature of the VO₂-window house rose from ambient to 29.5°C; the house with the 1.7%W-VO₂ window rose to 28.8°C, for a 16% improvement in energy efficiency vs VO₂, and 37% vs normal windows.

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