Ultra-efficient Radiative Cooling Nanocomposites

OBJECTIVES

Cooling below the ambient using radiative cooling

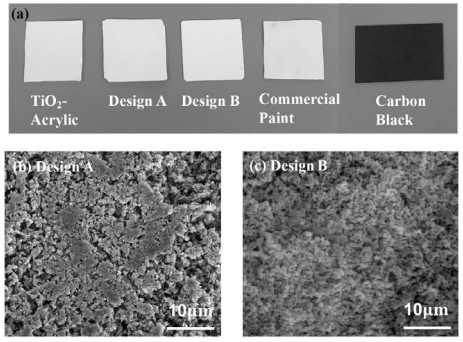
- Cooling represents a major sector of power consumption
- We aim at cooling surfaces below the ambient via the passive radiative cooling
- High reflectance in the solar spectrum is needed to minimize solar heating
- High emissivity in the sky window (8-13 μm) is needed to maximize heat loss to the deep sky.

METHODS

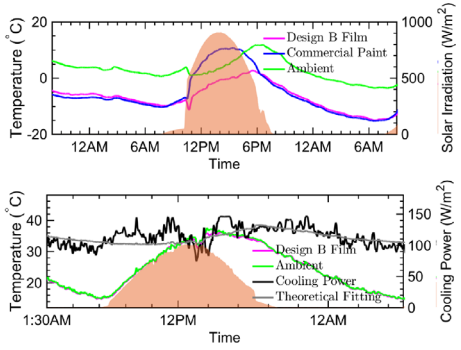
Solar-reflective infrared-emissive nanocomposites

- We choose the nanocomposite which is high performance and low cost
- We engineer the material, nanoparticle size, and concentration to scatter and reflect the sunlight strongly
- The spectral reflectance, transmittance, and reflectance are measured by UV-Vis-NIR and FTIR spectrometers
- Outdoor experiments have been performed to demonstrate the below-ambient cooling and to quantify the cooling power.

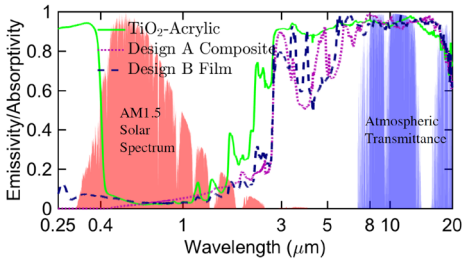
KEY RESULTS AND FINDINGS:



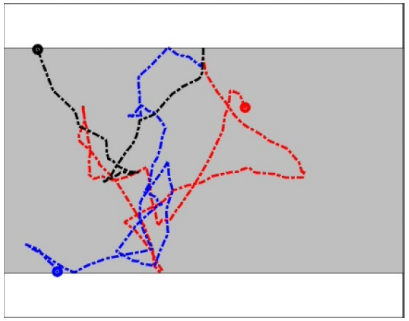
Top: Our nanocomposites (Designs A and B) as well as benchmarks (carbon black, commercial paint, and TiO2-acrylic). Bottom: The SEM (scanning electron microscope) images of our nanocomposites (Designs A and B).



Top: Our nanocomposites can be cooled 10 °C below the ambient during night time, and 6 °C below the ambient during noon. Bottom: Our cooling nanocomposites provide >100W/m² cooling power through 24-hour run.



Spectrometer measurements confirm that our nanocomposites have high solar reflectance and high emissivity in the sky window.



Monte Carlo simulations of the photon reflectance, transmittance, and absorptance

QUANTITATIVE IMPACT

Impact

- The first demonstration of below-ambient cooling under direct sunlight using particle-matrix nanocomposites
- Our nanocomposites are ultra-efficient, low cost, and compatible with current paint manufacturing technologies.
- A full patent has been filed.

Applications

- Cool roofs of residential and industrial buildings, data centers, outdoor electronics equipment, etc
- Cell phone skin temperature management
- Mitigate global warming!

Selected Publications

- Li, Peoples, Huang, Zhao, Qiu, and Ruan, Cell Rep. Phys. Sci. in press (2020). A *Cell* sister journal.
- Peoples, Li, Lv, Qiu, Huang, and Ruan, *Int. J. Heat Mass Trans.* **131**, 487-494 (2019)
- Huang and Ruan, *Int. J. Heat Mass Transfer* **104**, 890-896 (2017).