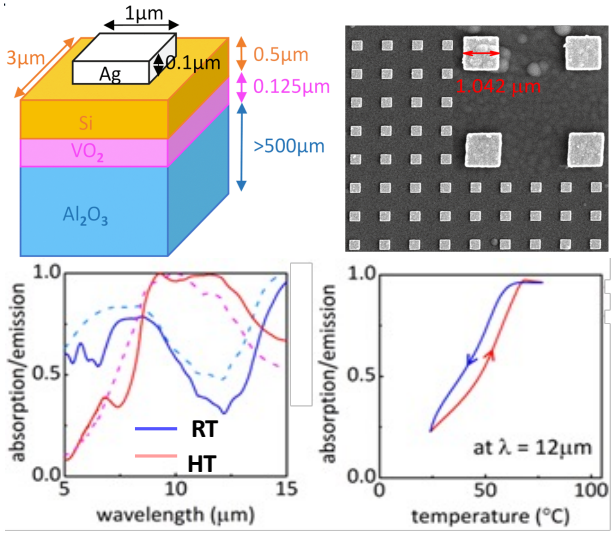
Metasurface-Enabled Passive Thermal Control for Stable Terrestrial and Spacecraft Applications

Scientific Achievement

Demonstration of an environmentally friendly metasurface using vanadium dioxide (VO_2) that offers responsiveness to ambient temperature. The metasurface enables passive thermal management by self-adjusting its absorptivity and emissivity response over a broad bandwidth ranging from visible to mid-infrared (IR) wavelengths.



Schematic of a VO2 based passive thermal control metasurface (top-left). SEM image (top right) of the fabricated passive thermal control metasurface on VO2 film. Measured emissivity response of the fabricated sample (bottom-left) at room temperature (RT) and at high temperature (HT). Measured hysteresis at wavelength 12µm (bottom-right).

Significance and Impact

The proposed durable and eco-friendly metasurface will be an excellent candidate for essential passive thermal regulation systems across residential and terrestrial applications.

Research Details

- Design uses a few-layer metasurface comprising a thin VO_2 film, amorphous silicon (α-Si) spacer layer, and top surface metal patch array.
- The metasurface exhibits desirable radiative cooling characteristics above the critical phase transition temperature of VO_2 and absorber at room temperature.

Singh, L.; Qiu, E.; Cardin, A.; Chen, A.; Luk, T.; Schuller, J.; Dalvit, D.; Schuller, I.; Kort-Kamp, W.; Azad, A. Passive Radiative Thermal Management Using Phase-Change Metasurfaces. *Journal of Physics: Photonics* 7, 025028 (2025).

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