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Case ID:M21-256P^
Published: 4/25/2022

Enhanced Infrared Emission with Scalable Microstructured VO2 Metasurfaces

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Background The performance of radiative heat dissipation through a surface depends heavily on the radiative properties of the surface, which are usually static or a weak function of temperature. Dynamic control of radiative properties has attracted increasing interest because of the ability to adapt to the changing environment and the promise of greater energy savings. One key to dynamic radiative thermal control lies in materials whose radiative properties are tunable in response to external stimuli. Such materials include vanadium dioxide (VO2) which can undergo a reversible phase transition from an insulating state to a metallic state when its temperature exceeds 68°C. This structural change causes a significant change in optical properties, making VO2 attractive for dynamic radiation control. One challenge in utilizing VO2 for dynamic thermal control is that the emittance of a pristine VO2 film decreases as it becomes metallic. This means that at high temperatures, when cooling is most desired, the emittance actually drops. Nanophotonic and metamaterial structures have been proposed to address this property mismatch and achieve the desired switch of thermal emittance. VO2-based multilayer devices have been theoretically designed for active radiative cooling and radiative thermostats. However, very few studies have experimentally achieved significantly increased emissivity at higher temperatures with VO2-based metamaterials. Additionally, the rare examples that exhibit tunable infrared emittance are fabricated using processes that will be difficult and/or expensive to scale to a level beyond laboratory experiments. Invention Description Researchers at Arizona State University have demonstrated enhanced infrared emission by thermally switching the excitation of magnetic polariton with a microstructured VO2 metasurface. This metasurface was fabricated on a HfO2 surface via scalable and etch-free processes. Upon VO2 phase change, the metasurface exhibited a 3X improvement in total emittance and a 6X increase in radiative thermal conductance compared to a non-nanostructured VO2. The tunable emittance spectra are also insensitive to incidence and polarization angles such that the VO2 metasurface can be treated as a diffuse infrared emitter. Potential Applications • Dynamic radiative heat dissipation • Thermal management • Noncontact thermal power conversion • Radiative refrigeration Benefits and Advantages • Scalable and etch-free fabrication process • Significant improvements in emittance and radiative thermal conductance • Demonstrated thermal stability and consistent performance after heating-cooling cycling Related Publication: Enhanced Infrared Emission by Thermally Switching the Excitation of Magnetic Polariton with Scalable Microstructured VO2 MetasurfacesResearch Homepage of Professor Liping Wang