

Effective Radiative Cooling by Microsphere-Based Disordered Photonic Coatings

Sarun Atiganyanun,¹ John B. Plumley,¹ Seok Jun Han,¹ Kevin Hsu,¹ Jacob Cytrynbaum,¹ Thomas L. Peng,² Sang M. Han,¹ and Sang Eon Han¹

¹Chemical and Biological Engineering, University of New Mexico, Albuquerque, New Mexico 87131, United States

²Air Force Research Laboratory, Kirtland AFB, New Mexico 87117, United States

Radiative cooling is a process in which an object passively loses heat via radiation and thus has a potential to reduce consumption of electricity used for thermal management. Toward a goal of making radiative cooling technology more accessible, we investigated two scalable, and inexpensive methods for fabricating microsphere-based structures that can achieve efficient radiation cooling. Specifically, colloidal sedimentation method and spray coating were employed to create coatings that consist of randomly arranged SiO₂ microspheres. With a systematic study of light scattering in microsphere-based disordered media, we showed how structural parameters influence radiative cooling performance. By combining this understanding with the two facile fabrication methods, we demonstrated that black substrates coated with our microsphere-based materials achieved substantial cooling below ambient temperature even under direct sunlight. Our coatings also outperformed commercially available paints designed for daytime cooling, without use of sophisticated fabrication process or expensive materials. We demonstrated further that solar scattering properties of our microsphere-based structures were improved by using hollow polymer microspheres instead of solid particles and that mechanical durability was enhanced when the hollow microspheres were embedded in a silicone matrix. Overall, this work provides a path toward wider applications of radiative cooling achieved by microsphere-based disordered systems.