**Surpassing the Conventional Limit of Response to Heat Radiation**

**by Nanophotonic Structures**

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The energy and environmental challenges we face today require a radical transformation of energy conversion and heat management systems to make them highly efficient, environmentally friendly, and inexpensive. Nanotechnology can potentially provide novel solutions for managing various forms of renewable energy including solar radiation. In particular, nanoscale light manipulation plays a crucial role in enhancing photovoltaic efficiency in solar cells and cooling efficiency in building heat management. In this talk, I will discuss how we can increase the photovoltaic efficiency and cooling efficiency by clever design of nanostructures.

First, I will discuss how symmetry in photonic nanostructures can be controlled to efficiently trap sunlight in solar cells and thus reduce the solar module cost. I will demonstrate the first experimental realization of such symmetry control in periodic nanostructures using simple, manufacturable wet etching methods on conventional silicon wafers. Even without symmetry control, our nanostructures have experimentally achieved a remarkable photovoltaic efficiency of 15.7% with silicon films that are 10 times thinner than those in conventional solar cells. Our further experimental study indicates that symmetry control with the manufacturable methods would enhance the photovoltaic efficiency to 17.4%.

Second, I will discuss how nanophotonic materials can passively cool building surfaces under intense summer sunlight, even below the ambient temperature. We have created randomly nanostructured coatings that are inexpensive and amenable to high throughput processing for manufacturability. Our experiments demonstrate that black substrates underneath these coatings can be cooled below the ambient temperature by as much as 12 °C under the sunlight. Our coating also outperforms commercial solar-reflective white paint. The average temperature of the substrate under our coating is 4.7 °C below that of the substrates coated with the commercial paint during the time of strongest sunlight. At the heart of this remarkable cooling effect lies the fundamental principle of light scattering and heat transfer. Our systematic study on light scattering enabled the realization of such effect and I will discuss the details of this study.

Lastly, I will present one of my future research directions that is inspired by biological structures. Certain biological structures display exceptionally strong light scattering power. Despite the significant advances made in understanding light scattering in random media, man-made white materials have not been able to match the nature’s performance. I will discuss how we will mimic such biological structures in an intriguingly unique way, to realize cooling coatings that surpass the conventional light-scattering limit.