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Colloquium

Mechanical Engineering Lecture in Energy Science and Engineering

From Nanoscale Surface Engineering to Macroscale Thermal Energy Systems

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Nanoengineered surfaces and materials have exciting, untapped potential to improve thermal energy systems. In this talk, I provide a few examples of how we leverage nanoscale manipulation capabilities to develop advanced thermal management and solar thermal energy conversion devices. First, I discuss our recent work that harnesses novel surface designs to control and manipulate phase-change processes. We demonstrate the ability to rapidly and reversibly turn nucleate boiling "on and off" and thus alter heat transfer performance up to an order of magnitude through molecular manipulation of the boiling surface. In flow boiling, we show that microstructures can increase flow stability and enhance heat dissipation capability via capillary wicking. Next, I discuss how nanoengineered surfaces can also be used to increase the efficiency of solar thermophotovoltaic devices. By engineering the spectral properties and defining the active area of the emitter with respect to the absorber, we achieve solar-to-electrical conversion efficiencies of 6.8%, exceeding that of the underlying cell. These nanoengineering approaches promise to address many of the pressing challenges in next generation thermal systems.