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Nanoengineered Materials for Advanced Energy and Water Technologies

Nanoengineered materials have exciting, untapped potential to improve energy and water technologies. First, I discuss our recent work that harnesses novel surface designs to control and manipulate phase-change processes for advanced thermal management and power generation. We demonstrated high flux evaporation from ultra-thin nanoporous membranes. We fabricated ≈200 nm thin nanoporous (≈130 nm pore diameter) membrane devices which reduced the thermal-fluidic transport resistance and accurately monitored the temperature of the liquid-vapor interface. At steady state, we demonstrated high heat fluxes across the interface (≈ 500 W/cm2) with pure evaporation into an air ambient. I then discuss nanostructured surfaces that can repel liquids even during condensation. This surface consists of isolated reentrant cavities with a pitch on the order of 100 nm to prevent droplets from nucleating and spreading within all structures. We demonstrated repellency to 10 °C below the dew point and showed durability over three weeks. Finally, I discuss a new water harvesting device to address water scarcity challenges in arid climates. We demonstrate an air-cooled sorbent-based atmospheric water harvesting device using the metal−organic framework (MOF)-801 operating in an exceptionally arid climate (10–40% RH) and sub-zero dew points. We predict that this device delivered over 0.25 L of water per kg of MOF for a single daily cycle. These nanoengineered materials approaches promise to address some of our pressing challenges in energy and water.

Evelyn N. Wang is the Gail E. Kendall Professor and Department Head in the Mechanical Engineering Department at MIT. She received her BS from MIT, and MS and PhD from Stanford University in Mechanical Engineering. From 2006-2007, she was a postdoctoral researcher at Bell Laboratories. Her research interests include fundamental studies of micro/nanoscale heat and mass transport and the development of efficient thermal management, solar thermal energy conversion, and water harvesting systems. Her work has been honored with awards including 2008 DARPA Young Faculty Award, the 2011 Air Force Office of Scientific Research Young Investigator Award, the 2012 Office of Naval Research Young Investigator Award, the 2012 ASME Bergles-Rohsenow Young Investigator Award, the 2016 ASME EPPD Women Engineer Award, and the 2017 ASME Gustus L. Larson Award. She is an ASME Fellow.