

Ambient centric thermal management with phase-variant liquid-infused surfaces

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ABSTRACT

Advanced terrestrial and space systems—ranging from electric vehicles and battery packs exposed to seasonal extremes on Earth to satellites experiencing intense solar heating and deep-space cooling—encounter highly dynamic thermal environments. Effective thermal management under such contrasting conditions is essential to ensure the reliability and performance of electronics, batteries, and associated components. This talk presents an ambient-centric thermal management strategy that employs thermos-responsive phase-variant liquid-infused surfaces (PV-LIS) to actively regulate heat transfer at the condenser. A PV-LIS is developed by infusing bio-friendly, food-grade coconut oil into a nanostructured CuO substrate. The infused oil exhibits a solid-to-liquid phase transition near 25 °C, enabling the surface to reversibly switch between film-wise and dropwise condensation modes with temperature. This dynamic wettability control allows the surface to autonomously adapt its heat transfer rate to the surrounding environment—minimizing heat loss in cold conditions (winter or eclipse periods) and enhancing heat rejection in hot conditions (summer or sun-facing exposure). Experimental results show that the PV-LIS achieves a 3.8× lower heat transfer coefficient at low condenser temperatures and a 1.9× enhancement at higher temperatures compared to a smooth copper surface. These findings establish design principles for adaptive, energy-efficient, and self-regulating two-phase thermal management systems, relevant to both terrestrial battery applications and next-generation space technologies.

ABOUT THE SPEAKER

Girish Kumar Marri is currently a Research Fellow at Nanyang Technological University (NTU), Singapore. He obtained his B.Tech from Rajiv Gandhi University of Knowledge Technologies, Andhra Pradesh, and completed his M.S. and Ph.D. degrees from the Indian Institute of Technology (IIT) Madras in 2015 and 2021, respectively. Prior to joining NTU, he worked as an Early Career Fellow at IIT Gandhinagar through a competitive early career research fellowship. His research interests include ambient-centric thermal management, phase change materials, electronic cooling, internal and external thermoregulation of Li ion Batteries, and development of machine learning models for heat and fluid flow systems.



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