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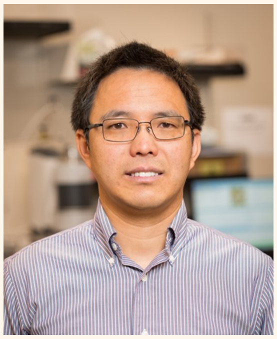
Location: CBB 104

Thermal Transport under Extreme Conditions



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ABSTRACT:

Thermal transport underlies many critical processes that power the modern world—including refrigeration and air conditioning, electronic chip cooling, thermal–electrical power generation, and industrial heating. A growing challenge is to enable these processes to operate reliably under extreme conditions, such as high temperatures and high heat fluxes.

In this talk, I will present three recent examples of our work addressing these challenges. First, we have investigated thermal energy conversion and management at high temperatures (above 700 °C), a frontier relevant to solar-thermal energy conversion, thermal energy storage, and industrial heating. Our work has focused on thermal characterization, materials development, device design—ranging from heat transfer in high-temperature materials for solar thermal applications [1], to thermal insulation [2], and selective infrared emitters. Second, as climate change drives more frequent extreme heat events, providing personal thermal comfort for people working in hot outdoor environments has become increasingly pressing. We are developing wearable thermoelectric devices that offer tunable cooling while addressing the challenge of dissipating heat into hot and humid ambient conditions (>40 °C, >50% RH) [3–5]. This requires precise control of heat transfer in flexible textiles and wearable heat sinks. Finally, we focus on thermal management for next-generation electronic devices, such as AI data center chips, which experience extreme heat fluxes approaching ~1000 W/cm^2—nearly one-sixth of the flux from the solar surface. We have demonstrated stable and high-flux evaporation cooling using a porous fiber-membrane platform capable of sustaining >800 W/cm^2 [6]. I will discuss the fundamental limits of this evaporation process, as well as engineering opportunities for developing evaporation cooling technologies.

BIOGRAPHY:

Renkun Chen is a Professor in the Department of Mechanical and Aerospace Engineering and the Program in Materials Science and Engineering at the University of California, San Diego. He received his B.S. in Engineering Thermophysics from Tsinghua University (2004) and Ph.D. in Mechanical Engineering from the University of California, Berkeley (2008). After a postdoctoral fellowship at Lawrence Berkeley National Laboratory, he joined UC San Diego in 2009. His research group at UCSD investigates micro- and nanoscale heat transfer and its applications in energy, electronics, and bio-systems. He has received an R&D 100 Award and a Hellman Fellowship. He has supervised more than a dozen Ph.D. students, many of whom have gone on to successful careers in academia and industry.

[1] Phys. Rev. E 109.4 (2024): L042902
[2] Adv. Mater. 37 (6) (2024), 2406732
[3] Sci. Adv., 5(5) (2020), eaaw0536.
[4] Adv. Mater. Tech. 10 (7) (2024), 2401690
[5] Cell Rep. Phys. Sci., in press (2025), arXiv:2501.08342
[6] Joule 9 (2025), 101975