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Advancing Boiling and Water Electrolysis Performance via Gas–Liquid Interface Control and Engineered Porous Structures

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Abstract

Improving energy efficiency through interfacial control is a central challenge for sustainable thermal and electrochemical systems. In this talk, recent progress in our laboratory toward unifying the physics of boiling heat transfer and water electrolysis will be presented. Both systems exhibit performance limits governed by gas–liquid interfacial phenomena — the critical heat flux (CHF) in boiling and the critical current density (CCD) in electrolysis — which can be substantially enhanced through precise control of capillarity, vapor/gas venting, and liquid replenishment using engineered porous structures.

The talk will highlight two key advances:

(1) new insights into capillarity-driven liquid supply and vapor removal in bi-layer honeycomb porous plates, enabling record-high CHF (>5 MW/m²) and stable local boiling, and

(2) the application of these interfacial control principles to alkaline water electrolysis, achieving enhanced CCD and reduced overpotential by facilitating gas evacuation and electrolyte supply.

These results demonstrate that gas–liquid interface control provides a unified framework for improving both thermal and electrochemical transport processes, offering a pathway toward next-generation cooling and hydrogen-production technologies.