Planar Bridging-Droplet Thermal Diodes

VTIP 20-109: “Planar Bridging-Droplet Thermal Diodes”

THE CHALLENGE

Thermal diodes preferentially conduct heat in one direction but insulate in the reverse direction. They are of immense practical interest for smart thermal management of aircraft, electronics, and buildings. However, real-life implementation has been constrained by poor effectiveness (solid-state diodes), dependence on a gravitational orientation (thermosyphons), limited scalability (liquid-trap heat pipes), or fragility (jumping-droplet diodes).

OUR SOLUTION

Jonathan Boreyko and his team at Virginia Tech have developed a novel bridging-droplet thermal diode which uniquely avoids all the problems faced by currently available technology. Advantages to this new design include increased durability and a two-dimensional planar configuration. The diode is scalable, independent from gravity, made from practical materials, and effective. In the forward mode, the diode conducts sustained phase-change heat transfer by evaporating water from the wick, condensing vapor on a hydrophobic surface, and then “bridging it back into the wick.” In the reverse mode, the hydrophobic surface is heated, resulting in excellent insulating properties.

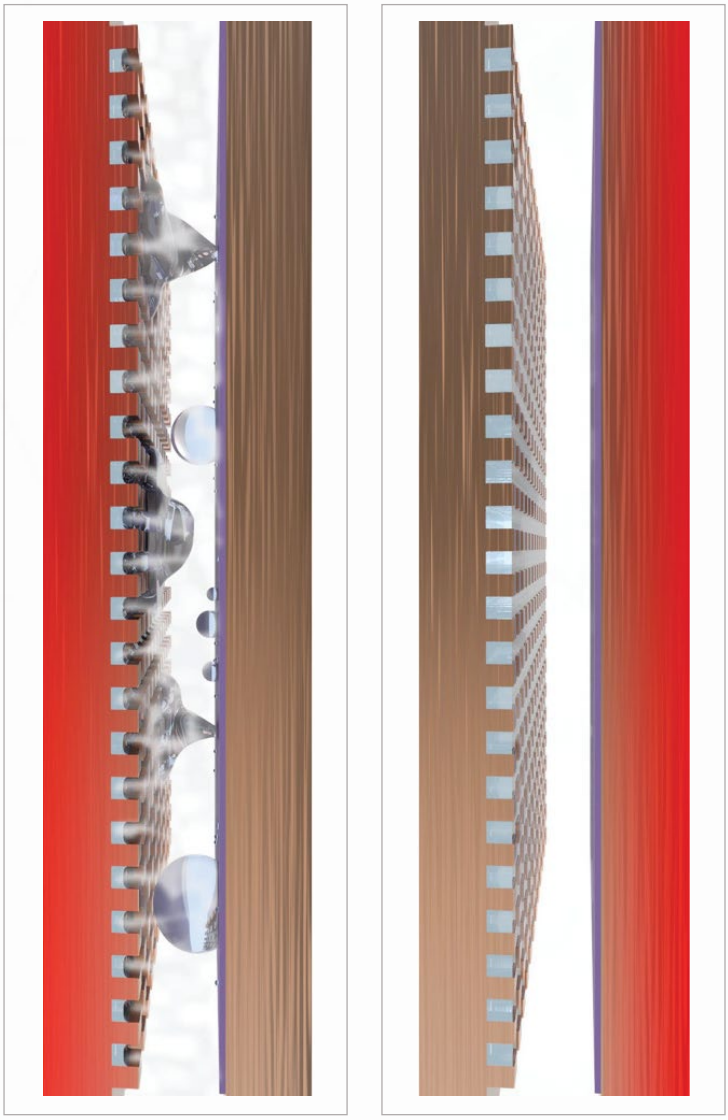

Diagram of the planar bridging-droplet thermal diode. The vapor chamber is comprised of a wick structure (red plate on the left) and an opposing plate (brown on the right) with a smooth hydrophobic coating (blue film). The box on the left shows the forward mode in which dropwise condensate bridges across the gap to return to the wicked evaporator. On the right is a schematic of the reverse mode in which the hydrophobic side is heated and the liquid is trapped in the opposing wick.

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