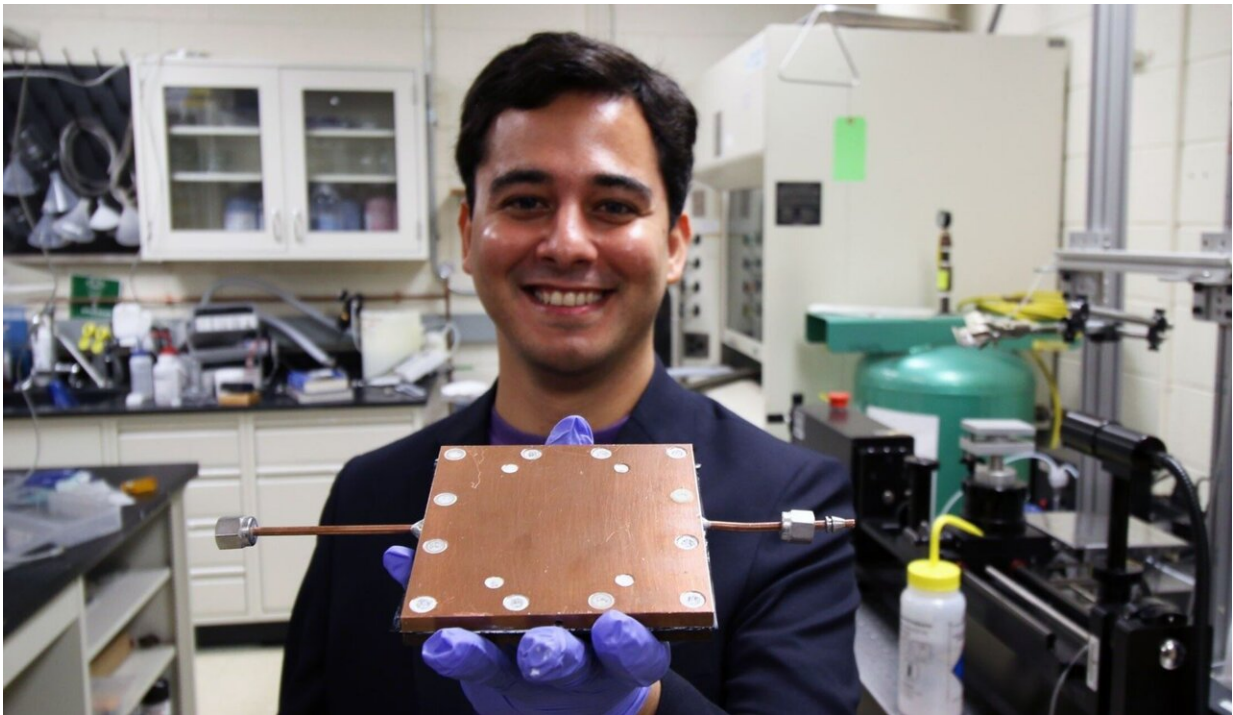


# Novel method of heat conduction could be a game changer for server farms and aircraft

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Lab member Mojtaba Edalatpour shows the thermal diode developed by Boreyko's team. Credit: Virginia Tech

Jonathan Boreyko, an associate professor in mechanical engineering, has developed an aircraft thermal management technology that stands ready for adaptation into other areas.

The research was published in *Advanced Functional Materials* on Aug. 18, 2020.

Boreyko was the recipient of a Young Investigator Research Program award in 2016, given by the Air Force Office of Scientific Research. This award funded the development of planar bridging-droplet thermal diodes, a novel approach to thermal management. Boreyko's research has shown this new approach to be both highly efficient and extremely versatile.

"We are hopeful that the one-way heat transfer of our bridging-droplet [diode](#) will enable the smart thermal management of electronics, aircraft, and spacecraft," said Boreyko.

Diodes are a special kind of device that allow heat to conduct in only one direction by use of engineered materials. For management of heat, diodes are attractive because they enable the dumping of heat entering one side, while resisting heat on the opposite side. In the case of aircraft (the focus of Boreyko's funding), heat is absorbed from an overheated plane, but resisted from the outside environment.

Boreyko's team created a diode using two copper plates in a sealed environment, separated by a microscopic gap. The first plate is engineered with a wick structure to hold [water](#), while the opposite plate is coated with a water-repelling (hydrophobic) layer. The water on the wicking surface receives heat, causing evaporation into steam. As the steam moves across the narrow gap, it cools and condenses into dew droplets on the hydrophobic side. These dew droplets grow large enough to "bridge" the gap and get sucked back into the wick, starting the process again.

If the source of heat were instead applied the hydrophobic side, no steam can be produced because the water remains trapped in the wick. This is

why the device can only conduct heat in one direction.

What does this look like in practice? An object producing heat, like a CPU chip, overheats if this heat is not continually removed. Boreyko's invention is affixed to this heat source. Generated heat is transferred through the conducting plate, into the water. Water turns to steam and moves away from the source of the heat. The hydrophobic, nonconducting side prevents heat from entering via the air or other heat sources that may be near, allowing the diode to manage the heat only from its main subject.

Boreyko's team measured a nearly 100-fold increase in heat conduction when the wicked side was heated, compared to the hydrophobic side. This is a significant improvement to existing thermal diodes. According to Boreyko, current diodes are either not very effective, only conducting a few times more [heat](#) in one direction, or require gravity. This new bridging-droplet thermal diode can be used upright, sideways, or even upside-down, and would even work in space where gravity is negligible.

**More information:** *Advanced Functional Materials* (2020).  
[onlinelibrary.wiley.com/doi/10.1002/adfm.202004451](https://onlinelibrary.wiley.com/doi/10.1002/adfm.202004451)

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