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Measuring heat across atoms

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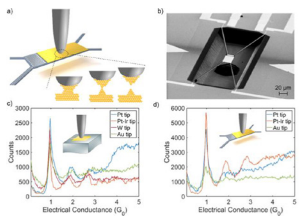
New paper introduces a novel approach to maximize thermal conductance across gold-gold atomic contacts.



As industry strives to develop next-generation electronics, from neuromorphic computing hardware to quantum sensing, heat has become an issue. To make the new electronics a reality, scientists must understand how heat moves between different materials and, ultimately, through single atoms. Current methods are too slow to measure the movement of heat from one atom to the next at room temperature.

"We need to transition away from shuttling huge amounts of data back and forth and develop computing architecture that is more like the human brain," said Bernd Gotsmann, a research staff member with IBM Research in Zurich. "To fully explore quantum transport effects in such novel devices, we want to be able to measure thermal transport across a single atom contact."

Gotsmann and a team of researchers at IBM and the Swiss Federal Institute of Technology explored the effect of tip material on thermal measurements at the atomic level. They studied the effect of three electrochemically etched metallic tips—platinum, platinum-iridium and tungsten—on the movement of heat between atoms.

The experimental design consisted of a break-junction setup that used Scanning Tunneling Microscopy (STM) on a suspended gold-covered membrane. A heater was included in the system to monitor the temperature.

Measuring the heat transport across a single gold atom contact, the researchers showed that the platinum and platinum-iridium tips were mechanically more stable, maximizing the time available to measure heat transport.

"With this experimental design, we show that we can hold a junction thinning down to one atom for 50 milliseconds at room temperature," Gotsmann said.

These findings offer new opportunities to combine STM imaging with thermal transport measurement for nano-applications. With this ability, it may be possible to improve the flexibility of future experimental techniques to understand thermal conduction across single molecules.

According to Gotsmann, this new method is limited to metals and requires many statistical analyses of large datasets to extract relevant data, but the insight gained from these experiments can be translated to other materials.

Source: "Quantized thermal conductance in metallic heterojunctions," by Nico Mosso, Alyssa Prasmusinto, Andrea Gemma, Ute Drechsler, Lukas Novotny, and Bernd Gotsmann, *Applied Physics Letters* (2019). The article can be accessed at https://doi.org/10.1063/1.5086483.