Scientists image conducting edges in a promising 2-D material

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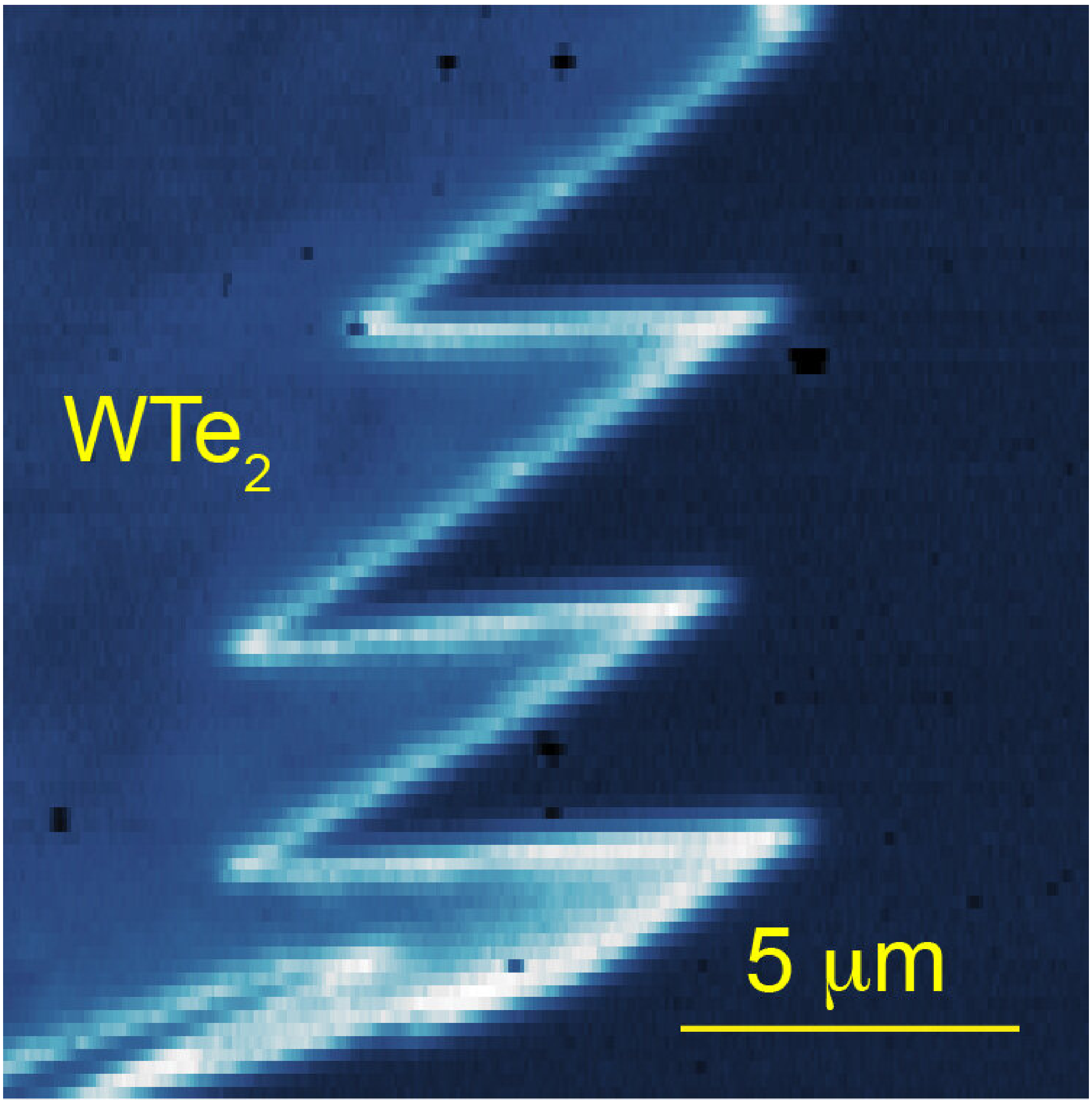


A typical MIM image near the corner of a monolayer WTe2 flake. The bright zigzag lines indicate conduction features precisely at the edges of the monolayer WTe2. Credit: Cui lab, UC Riverside.

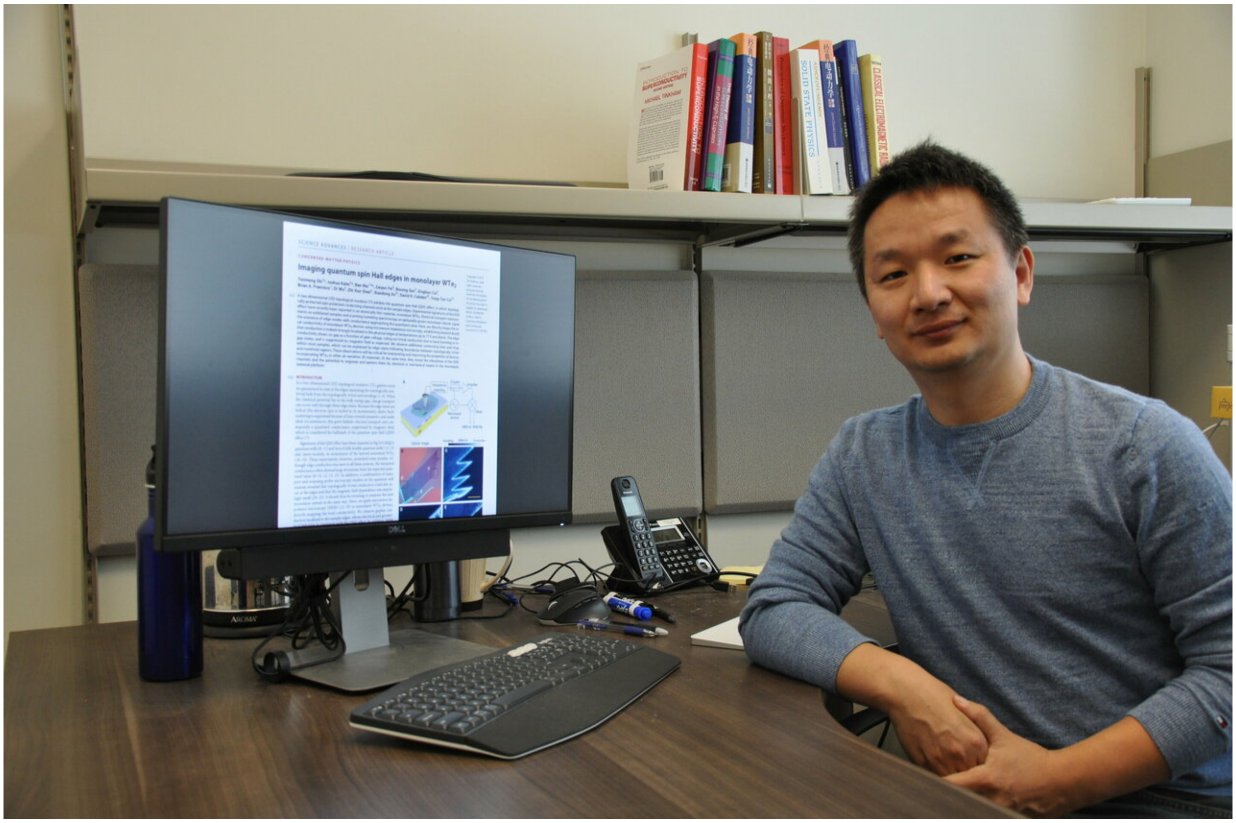
A research team comprised of scientists at the University of California, Riverside, and the University of Washington has for the first time directly imaged "edge conduction" in monolayer tungsten ditelluride, or WTe_2, a newly discovered 2-D topological insulator and quantum material.

The research makes it possible to exploit this edge conduction feature to build more energy-efficient electronic devices.

In a typical conductor, electrical current flows everywhere. Insulators, on the other hand, do not readily conduct electricity. In topological insulators, a special type of material, the interior works as an insulator, but the boundaries of such materials are guaranteed to be conductive due to its topological property, resulting in a feature called "topological edge conduction."

Topology is the mathematical study of the properties of a geometric figure or solid that is unchanged by stretching or bending. Applying this concept to electronic materials leads to discoveries of many interesting phenomena, including topological edge conduction. Working like highways for electrons, channels of topological edge conduction allow electrons to travel with little resistance. Further, because edge channels can be potentially very narrow, electronic devices can be further miniaturized.

Study results appear today in *Science Advances*.



Yongtao Cui is an assistant professor of physics and astronomy at UC Riverside. Credit: I. Pittalwala, UC Riverside.

"Several materials have been shown to be 3-D topological insulators," said Yongtao Cui, an assistant professor of physics and astronomy at UCR, who led the research. "But 2-D topological insulators are rare. Several recent experiments established that monolayer WTe_2 is the first atomically thin 2-D topological insulator."

Cui explained that for a 3-D topological insulator, conduction appears at its surfaces; for a 2-D sheet-like material, such conducting features are simply at the edges of the sheet.

Cui's lab used a novel experimental technique called Microwave Impedance Microscopy, or MIM, to directly image the conduction at the edges of monolayer WTe_2.

"Our results unambiguously confirm edge conduction in this promising material," Cui said.

Although WTe_2 has been known to exist for decades, interest in this material got a boost in only the last few years due to its exotic physical and electronic properties discovered using topological physics. WTe_2 layers are stacked together via van der Waals interactions and can be easily exfoliated into thin, 2-D, graphene-like sheets.

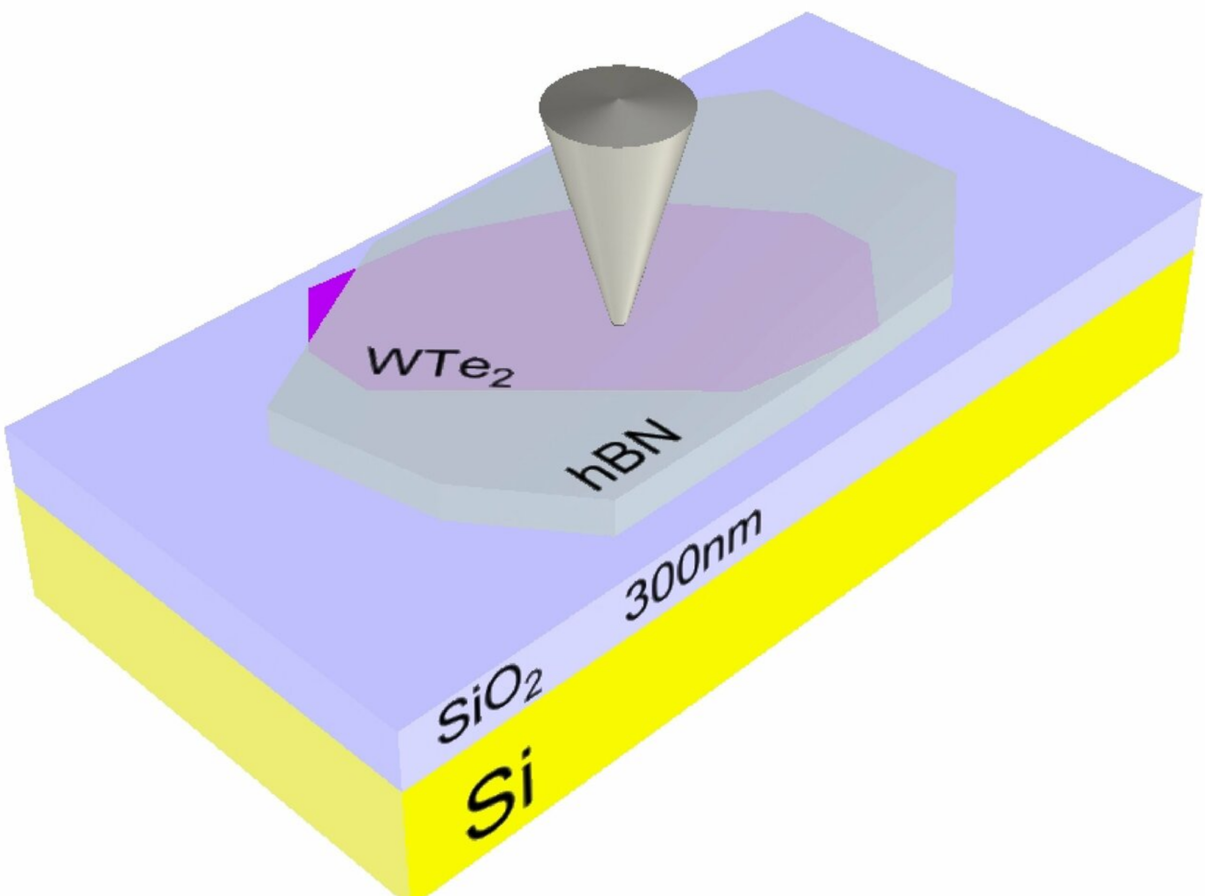


Illustration of the measurement setup. The monolayer WTe2 flake sits on a SiO2/Si substrate and is covered by a thin hexagonal boron nitride (hBN) flake to protect it from degradation. Credit: Cui lab, UC Riverside.

"In addition to conduction at the edges in monolayer WTe_2, we also found that the conductive channels can extend to the interior of the material, due to imperfections—such as cracks," Cui said. "Our observations point to new ways to control and engineer such conduction channels via mechanical or chemical means."

Cui's collaborators at the University of Washington prepared the monolayer WTe_2 samples. At UCR, his lab performed the MIM measurement, which involved sending a microwave electrical signal to a sharp metal tip, and positioning the tip near the surface of monolayer WTe_2. By resolving the microwave signal bounced back by the sample, the researchers could determine whether the sample region directly below the tip was conductive or not.

"We scanned the tip across the entire sample and directly mapped the local conductivity," Cui said. "We performed all the measurements at cryogenic temperatures, needed for monolayer WTe_2 to exhibit the topological property. The topological properties of monolayer WTe_2 can potentially serve as a platform to realize essential operations in quantum computing."

Cui's lab is already exploring new ways to manipulate the edge conduction channels and topological physics in monolayer WTe_2.

"We are looking into whether stacking monolayer WTe_2 with other 2-D materials can alter its topological property," he said. "We are also using mechanical and chemical methods to create networks of conduction channels. The MIM technique we used offers a powerful means to characterize the conduction channels in topological materials such as monolayer WTe_2."

More information: "Imaging quantum spin Hall edges in monolayer Wte2" *Science Advances* (2019). advances.sciencemag.org/content/5/2/eaat8799

Provided by University of California - Riverside