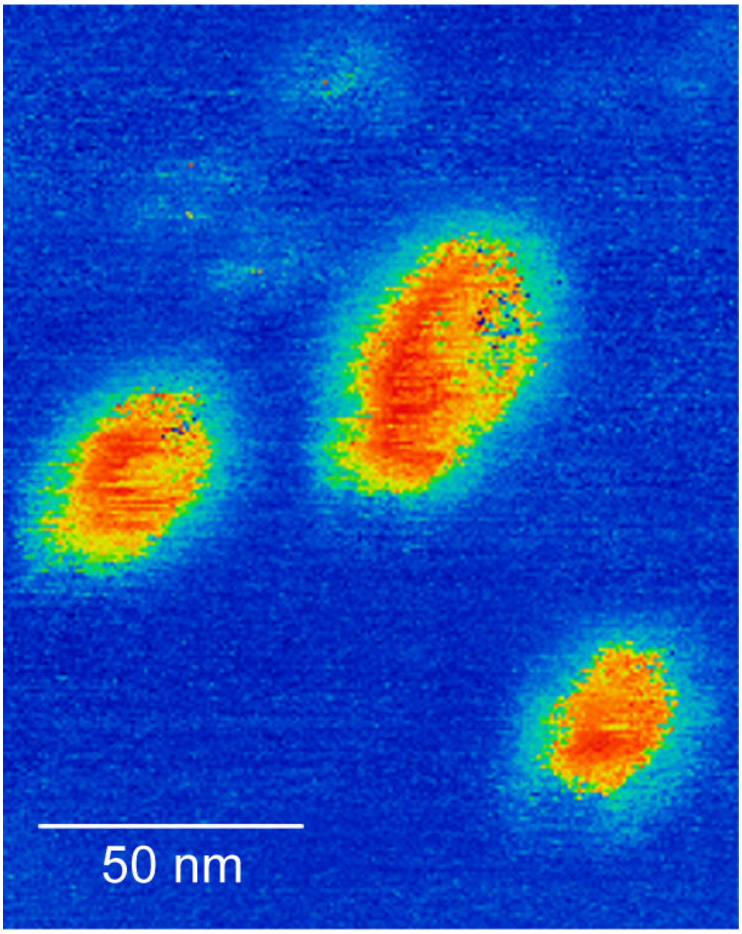
FIRST OBSERVATION OF NATIVE FERROELECTRIC METAL

July 5, 2019 Science 2 Views



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Ferroelectric domains in a WTe_2 single crystal (PFM imaging). Picture credits: Fleet

In an article published today in *Science Advances* Australian researchers describe the first observation of a native ferroelectric metal: a native metal with bistable and electrically switchable spontaneous polarization states-

1; the hallmark of ferroelectricity. The study found a coexistence of native metallicity and ferroelectricity in crystalline tungsten ditelluride (WTe $_2$) at room temperature. A Van der Waals material, which is both metallic and ferroelectric in its crystalline bulk form at room temperature, has potential for applications in nanoelectronics.

The study represents the first example of a native metal with bistable and electrically switchable spontaneous polarization states – the hallmark of ferroelectricity.

"We found the coexistence of native metallicity and ferroelectricity in crystalline tungsten ditelluride (WTe $_2$) at room temperature," explains study author Dr. Pankaj Sharma.

"We have shown that the ferroelectric state is switchable under an external electrical bias, and the mechanism for & # 39; metallic ferroelectricity in WTe $_2$ through a systematic study of crystal structure, electronic Transport measurements and theoretical considerations. "

" Van der Waals material, which is both metallic and ferroelectric in crystalline form at room temperature, has potential for new applications in nanoelectronics, "says the author. Feixiang Xiang.

Ferroelectric background

Ferroelectricity can be considered an analogy to ferromagnetism. A ferromagnetic material shows permanent magnetism and is in lay terms simply a "magnet" with north and south poles. Ferroelectric material also exhibits an analogous electrical property referred to as permanent electrical polarization resulting from electric dipoles consisting of equal but oppositely charged ends or poles. In ferroelectric materials, these electric dipoles are present at the unit cell level and lead to a non-vanishing permanent electric dipole moment.

This spontaneous electric dipole moment can be repeatedly switched between two or more equivalent states or directions upon application of a external electric field – a property used in many ferroelectric technologies, such as nanoelectronic computer memories, RFID cards, medical ultrasound transducers, Infrared cameras, submarine sonars, vibration and pressure sensors and precision actuators.

Traditionally, ferroelectricity has been used in materials that are more insulating or semiconducting than metallic because conduction electrons in metals shield the static internal fields resulting from the dipole moment.

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Model of tungsten ditelluride WTe $_2$ crystals in an orthorhombic layer structure. Picture credits: Fleet

The study

A ferroelectric semimetal at room temperature was published in July 2019 in *Science Advances* .

Bulk single crystal tungstitellite tellurium (WTe_2), which belongs to a class of materials known as transition metal dichalcogenides (TMDCs). They were studied by spectroscopic electrical transport measurements, conductivity atomic force microscopy (c-AFM) to confirm their metallic behavior, and by piezo-response force microscopy (PFM) mapping the polarization and detecting lattice deformation due to an applied electric field.

Ferroelectric domains – that is, the regions of opposite polarization direction – were visualized directly in freshly cleaved WTe_2 single crystals. 19659004] With spectroscopic PFM measurements with an upper electrode in a capacitor geometry, the switching of the ferroelectric polarization was demonstrated.

The study was funded by the Australian Research C. Work was carried out in part using the facilities of the NSW Node of the Australian National Fabrication Facility with support from the Australian Government's scholarship program

Density Functional Theory (DFT) calculations according to the first principle (University of Nebraska) confirmed the experimental results of the electronic and structural origins of the ferroelectric instability of WTe_2 supported by the National Science Foundation.

Ferroelectric Studies at FLEET

Ferroelectric materials are being intensively studied at FLEET (the ARC Center of Competence for Low Energy Technologies of the Future) for their potential use in low energy electronics beyond CMOS & # 39; ;Technology.

The switchable electric dipole moment of ferroelectric materials could be used, for example, as a gate for the underlying 2-D layer electron system in an artificial topological insulator.

Compared to conventional semiconductors, the very close (sub-nanometer) proximity of the electron dipole moment of a ferroelectric to the electron gas in the atomic crystal provides more efficient switching and overcomes the limitations of traditional semiconductors. Here, the conducting channel is buried a few tens of nanometers below the surface.

Topological materials are being investigated within the framework of FLEET's research theme 1, which aims to establish extremely low-resistance electronic paths capable of producing a new generation of extremely low-energy electronics.

Discovery of light-induced ferroelectricity in strontium titanate

Further information:

"A ferroelectric semi-metal for room temperature" *Science Advances* DOI: 10.1126 / sciadv.aax5080, https://advances.sciencemag.org/content/5/7/eaax5080

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First observation of native ferroelectric metal (5 July 2019)
retrieved on 5 July 2019
from https://phys.org/news/2019-07-native-ferroelectric-metal.html

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