FIRST OBSERVATION OF DOMESTIC FERROELECTRIC METAL

July 5, 2019 Science 7 Views

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(PFM imaging). Credit: FLEET "/>

Ferroelectric domains in a WTe single crystal (PFM imaging). Credit: FLEET

In a paper released today in *Science Advances* Australian researchers describe the first observation of a natural ferroelectric metal: a built-in metal with bistable and electrically switchable spontaneous polarization states-

1; the characteristic of ferroelectricity. The study demonstrated the coexistence of natural metallic and ferroelectricity in crystalline tungsten partial particles in bulk (WTe) at room temperature. A van der Waals material which is both metallic and ferroelectric in its bulk crystalline form at room temperature has the potential for nanoelectronics applications.

The study represents the first example of an embedded metal with bistable and electrically switchable spontaneous polarization states, characteristic of ferroelectricity.

"We found coexistence of native metallic and ferroelectricity in bulk crystalline tungsten particle (WTe) at room temperature," study author Dr. Pankaj Sharma.

"We showed that the ferroelectric state can be changed during an external electric bias and explain the mechanism of" metallic ferroelectricity "in WTe_2 through a systematic study of the crystal structure, electronic transport measurements and theoretical considerations."

"A van der Waals material that is both metallic and ferroelectric in its bulk crystalline form at room temperature has the potential for new nanoelectronics applications," says author Dr. Feixiang Xiang.

Ferroelectric backgrounder

Ferroelectricity can be considered a Analogous to Ferromagnetism A ferromagnetic material shows permanent magnetism, and in layman's terms, it is simply a magnet with the North and South poles Ferroelectric material likewise shows an analog electrical characteristic called a permanent electrical polarization derived from electric dipoles of equal opposite charged ends e In ferroelectric materials, these electric dipoles exist at the unit cell level and give rise to a non-disappearing permanent electrical dipole moment. This spontaneous electrical dipole moment can be repeatedly transmitted between two or more equivalent states or directions when applying an external electric field – a property used in a variety of ferroelectric technologies, for example, nano-electronic computer memory, RFID card, medical ultrasonic transducer, Infrared cameras, submarine sonar, vibration and pressure sensors and precision devices. Conventionally, ferroelectricity has been observed in materials which are insulating or semiconducting rather than metallic, because conduction electrons in metals cut out the static internal fields arising from the dipole moment.

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Model of tungsten ditelluride WTe 2 crystals in a layered orthorhombic structure. Credit: FLEET

The study

A room temperature ferroelectric semimetal was published in *Science Advances* in July 2019.
Bulk single crystal tungsten diethyluride (WTe_2), which belongs to a class of materials which called transition metal dicalcogenides (TMDC), were examined by spectroscopic electrical transport measurements, leading nuclear power microscopy (c-AFM) to confirm their metallic behavior and by piezo-response force microscopy (PFM) to map the polarization, detecting grid deformation due to an applied electric field. Ferroelectric domains, ie, the regions of oppositely oriented polarization direction, were directly visualized in freshly cleaved WTe [2] simple crystals. Spectroscopic PFM measurements with top electrode in a capacitor geometry were used to demonstrate switching of the ferroelectric polarization.
The study was supported by funding from the Australian Research C Ouncil through the ARC Center of Excellence in Future Low Energy Electronics Technologies (FLEET), and the work was conducted partly by NSW Nodes facilities of the Australian National Fabrication Facility, assisted by the Australian Government. Research Training Program Scholarship Scheme.

Calculations of the First Principle of Density Function Theory (DFT) (University of Nebraska) confirmed experimental findings of the electronic and structural origins of the WET 2 ferroelectric instability, supported by the National Science Foundation.

Ferroelectric Studies at FLEET

Ferroelectric materials are strongly studied at FLEET (ARC Center of Excellence in Future Low Energy Electronics Technologies) for their potential use in low energy electronics, "in addition to CMOS technology.

For example, switchable electrical dipole momentum for ferroelectric materials can be used as a gateway for the underlying 2-D electron system of an artificial topological insulator. In comparison with conventional semiconductors, the very close (sub-nanometer) ensures the proximity of a ferroelectric electron dipole moment to the electron gas in the atomic crystal. a more efficient changeover, overcome constraints of conventional semiconductors where the conduit channel is buried tens of nanometers below the surface. Topological materials are investigated within FLEET's research topic 1, which aims to establish ultra-low resistance electronic pathways to create a new generation v ultra low energy electronics.

Discovery of light-induced ferroelectricity in strontium titanate

More information:

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

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