Study of ferroelectric domain walls offers a new nanoscale conduction path

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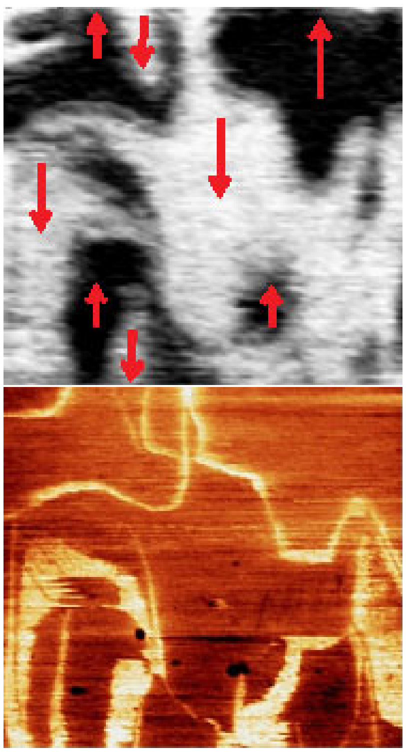

SPM images of the (110) surface of cleaved h-HoMnO3. (top) PFM image showing in-plane ferroelectric domains (oriented vertically, red arrows). (bottom) cAFM image showing enhanced conduction along tail-to-tail domain walls; images are 4 microns per side.

(PhysOrg.com) -- Facility users from Rutgers University together with the Center for Nanoscale Materials' Electronic & Magnetic Materials & Devices Group have identified two-dimensional sheets of charge formed at the boundaries of ferroelectric domains in a multiferroic material.

These two-dimensional charged sheets are not pinned by unstable defects, chemical dopants, or structural interface, but are formed naturally as the inevitable by-products of topological vortices. This discovery is an important step in understanding the semiconducting properties of the domains and domain walls in small-gap ferroelectrics.

It also suggests a new and natural platform for exploring transport of charge carriers confined at interfaces or surfaces, which is one of the major playgrounds in condensed matter physics for emergent phenomena.

The team focused on hexagonal $HoMnO_3$, which is a multiferroic material where antiferromagnetism and ferroelectricity coexist and — most intriguingly — magnetic, electric, and mechanical forces can be coupled to one another. In order to measure these various material properties simultaneously and on nanometer length scales, the researchers used in situ conductive atomic force microscopy (cAFM), piezo-response force microscopy (PFM), and Kelvin-probe force microscopy (KPFM) at low temperatures.

The results demonstrate that topological defects can be harnessed to stabilize charged 180-deg domain walls in multiferroics, opening up opportunities for a new kind of nanoscale conduction channel in multifunctional devices. Charged ferroelectric domain walls may provide novel platforms for creating a correlated two-dimensional electron gas without chemical doping.

More information: W. Wu et al., “Conduction of topologically-protected charged ferroelectric domain walls,” Phys. Rev. Lett., 108, 077203 (2012).