Turning a pinch of salt into an electrical switch

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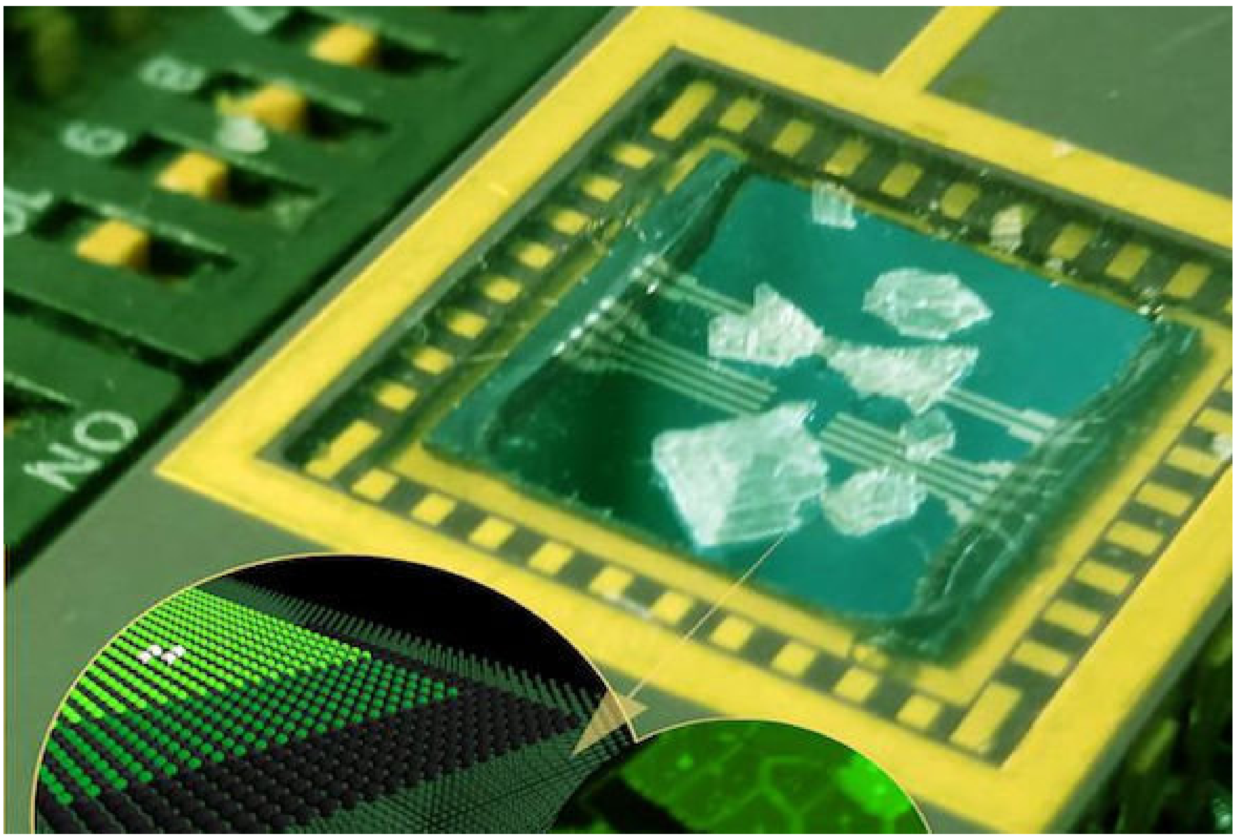

Credit: David Serrate and Jose Martinez Castro

A team of scientists from the University of Liverpool, University College London and the University of Zaragoza in Spain has discovered a way to induce and control a fundamental electrical switching behaviour on the nano-scale.

Their results are reported in the journal *Nature Nanotechnology*, where the team describe how separating an atomically thin layer of rock salt material – including ordinary table salt – from the surface of metallic copper by including an atomically thin layer of copper nitride in between creates a layer of so-called "electric dipoles," whose orientation can be switched by applying a large electric field.

When most materials are turned upside-down, they look the same at the atomic level and the electrical charges in the atoms cannot have a preference for orienting along a particular direction. In some materials, however, this symmetry is broken, and these charges can line up to form electric dipoles, which can be switched between multiple orientations with an electric field. If they remain in the same orientation after the electric field is removed, the material is commonly referred to as a ferroelectric which is the electrical analogue of a ferromagnet.

Because of the intrinsic switching behaviour of ferroelectrics there is a great interest in using nanoscale ferroelectrics for a new form of high density data storage. However, the outermost layers of a ferroelectric material often lose their ability to switch when they are incorporated into an electrical circuit. This makes it difficult to scale ferroelectric materials down to the atomic scale.

To overcome these difficulties, the scientists explored whether the new emergent properties of two-dimensional (2-D) materials which are only a few atomic layers thick could be exploited to create a different kind of dipolar switching material. These materials, can have properties that are dramatically different from those of their thicker counterparts.

The team started by forming an atomically thin layer of nitrogen and copper (copper nitride) on the surface of a copper crystal. On top of this, they deposited an atomically thin layer of rock salt material, specifically sodium chloride (ordinary table salt) and potassium bromide, which do not have net dipoles.

Professor Mats Persson, from the University's Department of Chemistry and the theorist of the paper, said: "This is a very exciting development and contrary to traditional wisdom that it is possible to have ferroelectric-like behaviour in atomically, thin layers in a metal-insulator junction"

Many of the most promising proposed applications for 2-D materials involve incorporating them into electrical circuits, so much attention has been focused on conducting 2-D materials. However, 2-D insulators are beginning to play an increasingly important role.

"By stacking two 2-D materials, even those that are insulators, we can create new behaviour that neither material would be able to exhibit individually. This opens a wealth of new possibilities for developing a new generation of 2-D material structures." remarked Cyrus Hirjibehedin, the project's lead scientist.

The paper "Electric polarisation switching in an atomically-thin binary rock salt structure" is published in *Nature Nanotechnology*.

More information: Jose Martinez-Castro et al. Electric polarization switching in an atomically thin binary rock salt structure, *Nature Nanotechnology* (2017). DOI: 10.1038/s41565-017-0001-2

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