# Physicists find unusual electronic properties in bismuth-based crystalline material

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Physicists at Rutgers University have discovered unusual electronic properties in a material that has potential to improve solar cell efficiency and computer chip design.

The scientists determined that a crystal made of bismuth, iron and oxygen can perform an electronic feat typically not feasible with conventional semiconductors. It acts as a reversible diode - essentially an electronic turnstile that lets current flow in one direction under certain conditions and in the opposite direction under different conditions. Traditional semiconductor diodes are not reversible - the direction of current flow that they allow is fixed during fabrication.

The researchers reported their findings today in a paper published in *Science* Express, an advance web posting of papers to be published in upcoming issues of the journal *Science*.

The scientists also discovered that diodes made from this material generate current when light falls on them, making the material a potential candidate for future solar cells. The material appears very sensitive to light at the blue end of the spectrum, a property that has the potential to increase solar cell efficiency.

"We've reached the upper limit of efficiency with today's solar cells," said Sang-Wook Cheong, physics professor in the School of Arts and Sciences and one of the paper's five authors. "While we still don't know how efficiently this material will ultimately perform as a solar cell, we

do need to keep investigating alternate technologies that show potential for improvement."

The crystal that Cheong and his colleagues investigated is a ferroelectric material, meaning that the crystal exhibits electrical polarization, or alignment. This polarization, which the scientists believe controls the crystal's ability to act as a diode, is known as a "bulk effect" - a characteristic that permeates the whole crystal. In contrast, traditional semiconductors act as diodes based on electrical effects at the interfaces between two different materials.

By applying an external voltage on the ferroelectric crystal, the polarization of the material reverses, along with the direction that the diode allows electricity to flow.

"This could make computer chip designs more flexible," said Cheong. "Engineers could design a single circuit element that performs one task under a certain configuration and another task under a different configuration."

The material belongs to class of crystalline materials known as perovskites, which have two positive ions of very different atomic sizes (in this case, bismuth and iron) bound to negative ions (in this case, oxygen). It has three oxygen atoms for each bismuth and iron atom.

Source: Rutgers University