Material scientists build ferroelectric memory device based on light response

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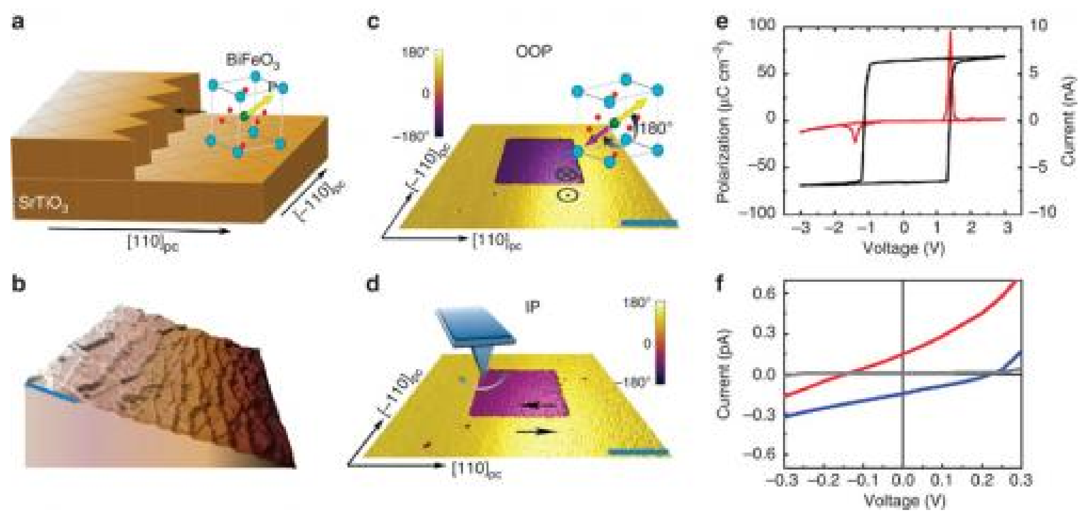

Properties of as-grown BiFeO3 thin films. Credit: *Nature Communications* 4, 1990 doi:10.1038/ncomms2990

(Phys.org) —Researchers in Singapore, with assistance from materials scientist Ramamoorthy Ramesh, of the University of California, have succeeded in building a prototype ferroelectric memory device that uses light to read its polarity. In their paper published in the journal *Nature Communications*, the team describes how they built their device and its properties.

Current computers use two main types of memory for storing data, electronic chips or hard disks. The types of memory chips used can be broken down into three types: RAM, ROM and DRAM (flash). RAM is fast but lasts only while electricity is present. ROM can only be used once and DRAM is much slower than RAM. For that reason, scientists have been studying other ways to store data—the goal is to create a memory device that runs as fast as RAM, but works even when the electricity is turned off.

One promising technology is ferroelectric RAM, or FRAM. Based on bismuth ferrite, such devices hold states of "0" or "1" based on polarization states, rather than electronic states. While promising they have thus far had one main drawback—using electricity to read the polarization state erases the data causing the need for it to be rewritten. Over time this results in the introduction of errors. In this new effort, the research team found a way around this problem by using light instead of electricity.

Back in 2009, a team of researchers at Rutgers discovered that ferroelectric memory devices had a photovoltaic property—shining a light on them caused electricity to be produced. The researchers in Singapore noted that the amount of electricity produced by a cell in such a device depended on the polarization state of the material—a "0" or a "1" could be assigned to the different amounts. Equally important was the fact that shining a light on the material didn't disturb its polarization state. They built a prototype and found it could be used as a fast memory device that holds onto data even when the power is turned off.

The researchers note that their prototype device is approximately 10,000 faster than DRAM and only requires 3 volts of electricity to read a cell, compared to the average of 15 volts for DRAM.

While certainly promising the new type of memory device has two big hurdles to jump before being considered for use in real-world devices. First it must be shown that it can be made a lot smaller, and second, a way must be developed to produce devices where individual beams of light can be used to control individual cells.

More information: Non-volatile memory based on the ferroelectric photovoltaic effect *Nature Communications* 4, 1990 doi:10.1038/ncomms2990 (Open paper)

Abstract
The quest for a solid state universal memory with high-storage density, high read/write speed, random access and non-volatility has triggered intense research into new materials and novel device architectures. Though the non-volatile memory market is dominated by flash memory now, it has very low operation speed with ~10 μs programming and ~10 ms erasing time. Furthermore, it can only withstand ~105 rewriting cycles, which prevents it from becoming the universal memory. Here we demonstrate that the significant photovoltaic effect of a ferroelectric material, such as BiFeO3 with a band gap in the visible range, can be used to sense the polarization direction non-destructively in a ferroelectric memory. A prototype 16-cell memory based on the cross-bar architecture has been prepared and tested, demonstrating the feasibility of this technique.

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