PRESS RELEASE

Picosecond accurate slow-motion confirms oxide materials exhibit considerably faster switching properties than do semi-conductors

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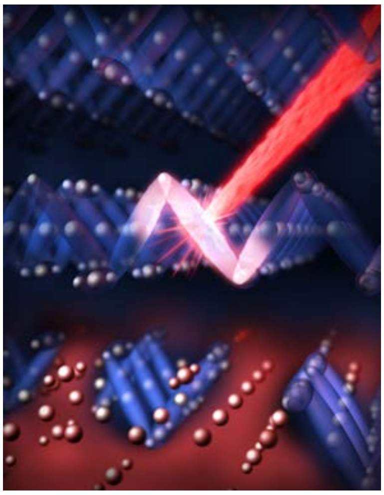
As part of an international team of researchers, scientists at the Helmholtz Center Berlin (HZB) have observed the switching mechanism from a non-conducting to a conducting state in iron oxide (specifically, magnetite) with previously unrealized precision. This switching mechanism - which, in oxides, proceeds in two consecutive steps and which is thousands of times faster than it is in current transistors - is described in the current epub-ahead-of-print issue of the scientific journal Nature Materials (DOI: 10.1038/NMAT3718).

Materials that have the ability to switch between being good conductors and being good insula-tors are considered good potential candidates for electronic building blocks – for use in transis-tors, for example. The iron oxide magnetite is the best known representative of this class of ma-terials. At low temperatures, magnetite has insulating properties; at high temperatures, the oxide is a good conductor. This switching mechanism however happens so quickly that it's been im-possible until now to fully grasp it on an atomic level.

Now, an international team of scientists at LCLS, the US source for ultrafast X-ray light at the SLAC National Laboratory, has managed to freeze the switching mechanism in ultraslow-motion. The researchers were able to document that the transition proceeds in two stages. "The first step involves the appearance of conducting islands within the insulating material. Thereaf-ter, it takes less than a picosecond (that is, one trillionth of a second) before the atoms re-organize to create a complete metallic grid," explains HZB's own Christian Schüßler-Langeheine.



Optical laser flash (red) destroys the electronic order (blue) in magnetite and, within one trillionth of a second, switches the state of the material from insulating to conducting.

Image: Greg Stewart, SLAC National Accelerator Laboratory

At BESSY II, the HZB operated electron storage ring, Schüßler-Langeheine and his team took care of the work that was necessary in preparation for the SLAC experiment. The insights gleaned from this work provided the basic framework for the SLAC experiment and for its suc-cessful realization.

The experiment, which was conducted in California, involved cooling magnetite to a temperature of minus 190 degrees. In a next step, the oxide was hit with laser light, the energy from which ended up prompting the switching mechanism. In place of a strobe light, the researchers used an X-ray laser pulse to observe the switching mechanism. Only a handful of photon sources in the World have the capabilities of performing these types of picosecond interval time-resolved measurements.

“At the HZB, we are doing research on materials for use in faster, more energy-efficient elec-tronics,” Christian Schüßler-Langeheine says. “Our experiment confirmed that the switch of an oxide material like magnetite can be incredibly fast. Oxides thus represent an exciting alternative to currently available semiconductors – especially the kinds of materials that also show metal insulator transitions at room temperature.”

The research was conducted jointly by scientists at the SLAC and Stanford University, the CFEL and Hamburg University, Amsterdam, Cologne, Potsdam, and Regensburg Universities, the Dresden-based MPI CPfS, the European Source for X-ray pulses ELETTRA in Trieste, the XFEL in Hamburg, the Advanced Light Source in Berkeley, and the Swiss Paul Scherrer Insti-tute. The samples were prepared at Purdue University.

Link to SLAC Press Release