Georgia State physicist, international researchers discover fastest light-driven process

EurekAlert!

A discovery that promises transistors – the fundamental part of all modern electronics – controlled by laser pulses that will be 10,000 faster than today's fastest transistors has been made by a Georgia State University professor and international researchers.

Professor of Physics Mark Stockman worked with Professor Vadym Apalkov of Georgia State and a group led by Ferenc Krausz at the prestigious Max Planck Institute for Quantum Optics and other well-known German institutions.

There are three basic types of solids: metals, semiconductors, used in today's transistors, and insulators – also called dielectrics.

Dielectrics do not conduct electricity and get damaged or break down if too high of fields of energy are applied to them. The scientists discovered that when dielectrics were given very short and intense laser pulses, they start conducting electricity while remaining undamaged.

The fastest time a dielectric can process signals is on the order of 1 femtosecond – the same time as the light wave oscillates and millions of times faster than the second handle of a watch jumps.

Dielectric devices hold promise to allow for much faster computing than possible today with semiconductors. Such a device can work at 1 petahertz, while the processor of today's computer runs slightly faster than at 3 gigahertz.

"Now we can fundamentally have a device that works 10 thousand times faster than a transistor that can run at 100 gigahertz," Stockman said. "This is a field effect, the same type that controls a transistor. The material becomes conductive as a very high electrical field of light is applied to it, but dielectrics are 10,000 times faster than semiconductors."

The results were published online Dec. 5 in Nature. The research institutions include the Max Planck Institute for Quantum Optics, the Department of Physics at the Munich Technical University, the Physics Department at Ludwig Maximilian University at Munich and the Fritz Haber Institute at Berlin, Germany.

At one time, scientists thought dielectrics could not be used in signal processing – breaking down when required high electric fields were applied. Instead, Stockman said, it is possible for them to work if such extreme fields are applied at a very short time.

In a second paper also published online Dec. 5 in Nature, Stockman and his fellow researchers experimented with probing optical processes in a dielectric – silica – with very short extreme ultraviolet pulses. They discovered the fastest process that can fundamentally exist in condensed matter physics, unfolding at about at 100 attoseconds – millions of times faster than the blink of an eye.

The scientists were able to show that very short, highly intense light pulses can cause on-off electric currents – necessary in computing to make the 1s and 0s needed in the binary language of computers -- in dielectrics, making extremely swift processing possible.

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